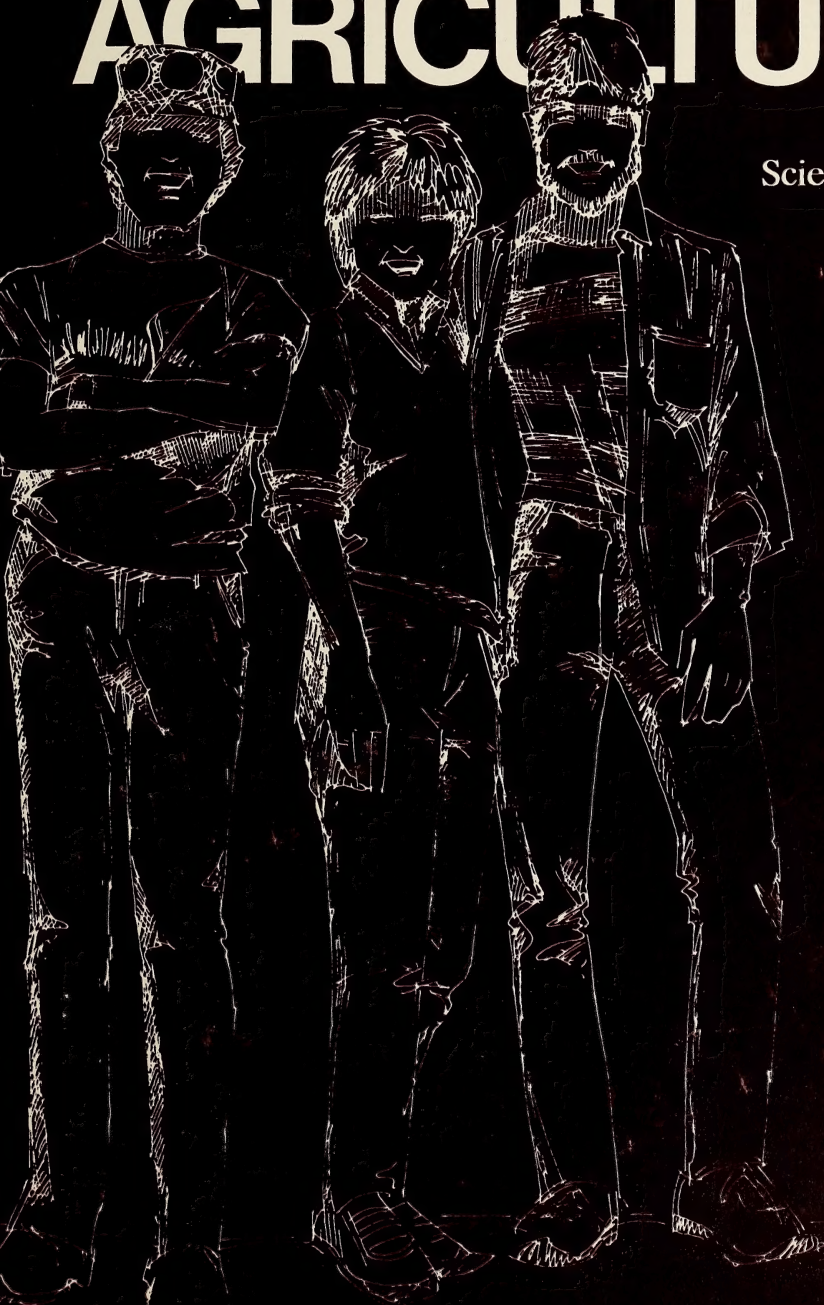


THE BUSINESS OF AGRICULTURE

Science 10, 20, 30



February 1989 500 copies
For Further Information Contact:

Alberta Agriculture
Ag. in the Classroom Program
2nd Floor, 7000 - 113 Street
Edmonton, Alberta
T6H 5T6

Ph: 427 -- 2402

APR 11 1989

INTRODUCTION

Welcome to the Business of Agriculture

This is one of a series of handbooks written by the Agriculture and Agri-Food Canada for senior high school students. It is part of the Alberta Program of Studies for the years 10, 20, and 30. The handbook is designed to help you learn about the business of agriculture and to develop your skills in the areas of science, mathematics, and communication.

THE BUSINESS OF AGRICULTURE

A Resource Book For Teachers

of

Science 10, 20, 30

In preparing this handbook we have focused on three aspects of the business of agriculture:

The importance of agriculture in our society

The need for scientific knowledge in agriculture

The role of the teacher in the classroom

Within these broad areas, the activities and projects are designed to help you understand the business of agriculture and to develop your skills in the areas of science, mathematics, and communication. The handbook is designed to be used as a resource for teachers and students alike. It is not intended to be a textbook, but rather a guide to help you learn about the business of agriculture and to develop your skills in the areas of science, mathematics, and communication.

**Alberta Agriculture
1989**

The Business of Agriculture is a series of handbooks written by the Agriculture and Agri-Food Canada for senior high school students. It is part of the Alberta Program of Studies for the years 10, 20, and 30. The handbook is designed to help you learn about the business of agriculture and to develop your skills in the areas of science, mathematics, and communication.

Digitized by the Internet Archive
in 2016

INTRODUCTION

Welcome to The Business of Agriculture!

This is one of a series of handbooks written by the Agriculture in the Classroom Program for teachers of senior high school students. It relates to the new Alberta Program of Studies for Science 10, 20 and 30. Other handbooks in the Division IV series will aim at the new Social Studies 10, 20, 30 series and at Career and Life Management 20, Theme D.

Modern agriculture is much more than farming. All materials from Agriculture in the Classroom focus on five concepts that characterize agriculture today:

- i diversity of enterprises
- ii production, processing and distribution system
- iii capital and technology intensity
- iv economic importance to society
- v importance of soil and water to production

Implications of these concepts link agriculture to all Albertans, and make it an important sponsor and user of scientific research.

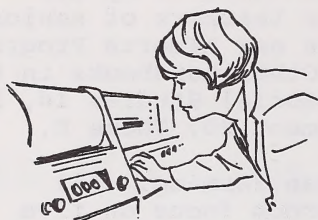
In preparing this handbook we have focused on three aspects of the nature of science:

- . the importance of detailed and quantitative observations
- . the need for explanatory theories tying apparently isolated phenomena together
- . the rule that theories must be subject to testing and disproof

Within these broad generalizations, the activities are designed to illustrate particular concepts in your program of studies. The first page of each activity outlines the curriculum fit and the particular concept, skills and attitudes addressed there. It also gives some guidance about time and materials you will need to run the lesson.

The Business of Agriculture: Science is meant to serve as a teacher's handbook. In writing the procedure sections for these activities, we intended them to be clear enough that you can use them "off the shelf" if you wish. However, they are only suggestions, and you are free to adapt them to suit your own needs and your students' interests.

Like all Agriculture in the Classroom materials this book is written to teachers like you. However, throughout the book there are certain specialty pages. These are identified graphically.



Pages marked with the symbol at left are extended references to you. They usually explain agricultural matters in more detail than can be managed within a procedure section.

The symbol to the right identifies a student task sheet. These are generally for recording observations or performing calculations.



Student data sheets carry this symbol. They contain information directly useful to the work required by task sheets.



This is a pilot version of The Business of Agriculture: Science. Later this school year we will be seeking your feedback on how activities work, any modifications you devise, where you want expansions or deletions and any other reactions you have. This process will enable us to produce a final version that any teacher can use effectively in their classroom.

The Alberta Agriculture File Library or Publications Office may have additional relevant resources. You can obtain a publication list or film catalogue by writing them at:

Information Services Division
Alberta Agriculture
7000 - 113 Street
Edmonton, Alberta
T6H 5T6



kind of a light system in the house of a student.
This is a light system in the house of a student.
This is a light system in the house of a student.
This is a light system in the house of a student.
This is a light system in the house of a student.
This is a light system in the house of a student.
This is a light system in the house of a student.
This is a light system in the house of a student.
This is a light system in the house of a student.
This is a light system in the house of a student.

Office of the
Director of the
Department of
Education
1000 - 11th Street
Edmonton, Alberta
T6N 1Y2



CREDITS

Production: Alberta Agriculture
Agriculture Education Branch

Writer: Cole Pederson

Proof Reading: Cole Pederson, Cindy Dixon,
Betty Gabert, June Gingras

Artwork: Roberta Mazurenko

Production and Layout: Roberta Mazurenko, Cindy Dixon

Project Management: Betty Gabert

Word Processing: June Gingras

CREDITS

5

Advised by: [illegible]
Advised by: [illegible]

Production:

Core Editor:

Editor:

Core Editor: [illegible]
Core Editor: [illegible]

Core Editor:

Robert: [illegible]

Robert:

Robert: [illegible]

Production and Layout:

Core Editor:

Project Management:

Core Editor:

Core Editor:

TABLE OF CONTENTS

SECTION A: SCIENCE 10

Activity 1:	Twisting by the Pool	1.1
	Students develop a water consolidation plan.	
Activity 2:	Got it Made in the Shade	2.1
	Students investigate the relationship between soil temperature and evaporation of water.	
Activity 3:	Keeping Warm by Freezing	3.1
	Students demonstrate that the heat given off when water freezes can prevent frost damage to plants.	
Activity 4:	Why Can't a Person Be More Like a Cow . . .	4.1
	Students translate written descriptions of a biological energy system into a systems diagram.	
Activity 5:	So How Good is it Really	5.1
	Students develop an evaluation procedure and apply it to agricultural products.	

SECTION B: SCIENCE 20

Activity 6:	Moldilox and the Five Pairs	6.1
	Students compare four ancient forms of food preservation on the basis of how well they prevent mold on bread.	

TABLE OF CONTENTS (con't)

Activity 7: Helping the Herbicide Handler's Headaches . 7.1

Students evaluate weed problems and choose from a set of herbicides the one that will best solve each problem.

Activity 8: It's a Gas 8.1

Students calculate the amounts of methane gas that can be expected from various farm operations.

Activity 9: Fueling the World of Wheels 9.1

Students identify the steps in producing fuel ethanol and evaluate its potential to replace gasoline in vehicles.

SECTION C: SCIENCE 30

Activity 10: Food For Plants 10.1

Students identify the reasons for adding nutrients to the soil, and learn how fertilizer is made.

Activity 11 Down in the Nutrient Valley 11.1

Students speculate on the nature of a society based on biodegradable plastics made from renewable resources.

TABLE OF CONTENTS (con't)

Activity 12: Designer Genes, Cut to Fit Your Needs . . . 12.1

Students act as a citizen
advisory board, recommending
policies on genetic engineering
research.

SECTION A: SCIENCE 10

In preparing material for Science 10 we have directed our attention to Units III, IV and V. Water, food energy and product testing are all major topics in agriculture, and can all be enhanced by agricultural examples.

Our first three activities all support concepts from Unit III: Importance of Water. In Activity One students are asked to design a water channelling and storage program to consolidate several scattered sloughs into a single large pond. Activity Two asks them to perform an experiment that will illustrate factors affecting soil moisture loss. Activity Three changes the focus, and concentrates on how phase changes in water can be used to modify plant temperatures.

Activity Four relates to Unit IV: Personal Energy Systems. In this lesson, students identify the structural differences between the human and ruminant digestive system and relate these structural differences to the different amounts of energy extracted from vegetable matter. At the same time they work at translating descriptive passages into flowchart notation.

Activity Five deals with the idea of testing procedures from Unit V: Product Evaluation. Students develop an evaluation grid and use it to rate one of several agricultural products.





ACTIVITY 1



Twisting By The Pool

Objectives:

Given a sample plot of land, students will plan a slough consolidation project.

Curriculum Fit:

Science 10, Unit III
Importance of Water

Science Concepts:

All life depends on the purity and availability of water. Many societal factors are involved in water management.

Skills:

Examine the effects of human behavior on the environment.
Develop and employ skills for accessing and processing information in a technologically advanced environment.

Attitudes:

Become aware of the interaction of societal factors such as financial, political, ethical and moral forces with science and technology.

Agriculture Concepts:

Dependence on Soil and Water
Capital and Technology Intensity

Cognitive Level:

Application, Synthesis

Materials Required:

Enclosed diagram
Tracing paper

Time Required:

Two 50-minute classes



BACKGROUND - For the Teacher

Drought and partial drought conditions on the North American prairies have brought water management issues to prominent news coverage in the last two years.

The need to extract maximum use from available water has produced numerous responses: modernizing irrigation systems, creating reservoirs and pumping ground water have all been used to supply water for growing crops.

Another technique that has proved useful in some situations is called "slough consolidation". This technique involves channelling small pockets of water into one large storage pond from which water can be pumped when needed.

As a result, snowmelt and early spring rain-water that would ordinarily be lost as runoff can be caught and stored for later use.

This lesson asks your students to evaluate a contour map of a farm, and to choose a way to connect several sloughs so they will drain to a single location. They must also calculate the volume of water that can be expected from the area being considered and the size of the storage reservoir.

You can run this lesson as either an individual or a group activity.



PROCEDURE

Part 1

Preparation:

1. Make as many copies of the student handout as you will need.
2. Consult the explanatory map. You may wish to convert it into an overhead transparency for your introduction.

Part 2

Introduction:

3. Explain that water shortages can occur during the growing season even in areas with enough annual precipitation to support crops. This lesson deals with one method of responding to this problem.
4. Using the sample map, explain how contour maps store and display geographic information.
5. Mark proposed changes on the sample map and show the second sample map with the altered contours.

Part 3

Activity:

6. Distribute the Student Activity Sheet. Look over and interpret the drainage pattern with your class.
7. Ask your students to map out a slough consolidation program that will concentrate standing water in one reservoir.

Part 4

Conclusion:

8. Have students present their consolidation plans. If there are several different solutions, discuss the reasons behind each.

DISCUSSION QUESTIONS

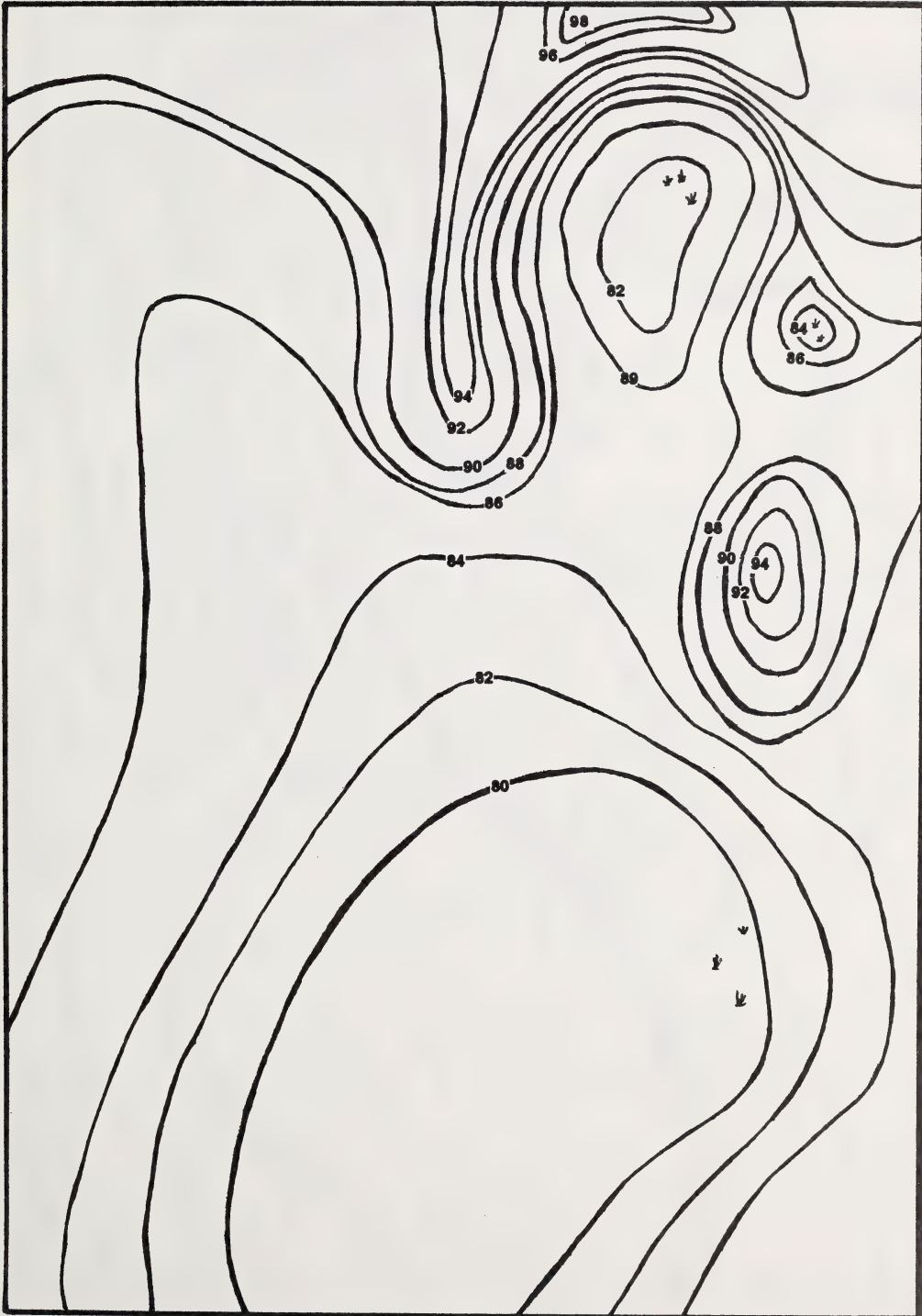
1. What is the advantage to a farmer of consolidating standing water to a single pond rather than letting it collect in several places?
2. In this exercise what area becomes open land and what is the final area of the storage pond?
3. What volume of water is produced by 10mm of rain on this plot of land?
4. If 60% of a rainfall soaks into the ground, how big a storage pond is needed for a 10mm storm?

RELATED ACTIVITIES

1. Evaluate several plots of land on their potential for spring run off collection.
2. Arrange a field trip to see a water conservation project.

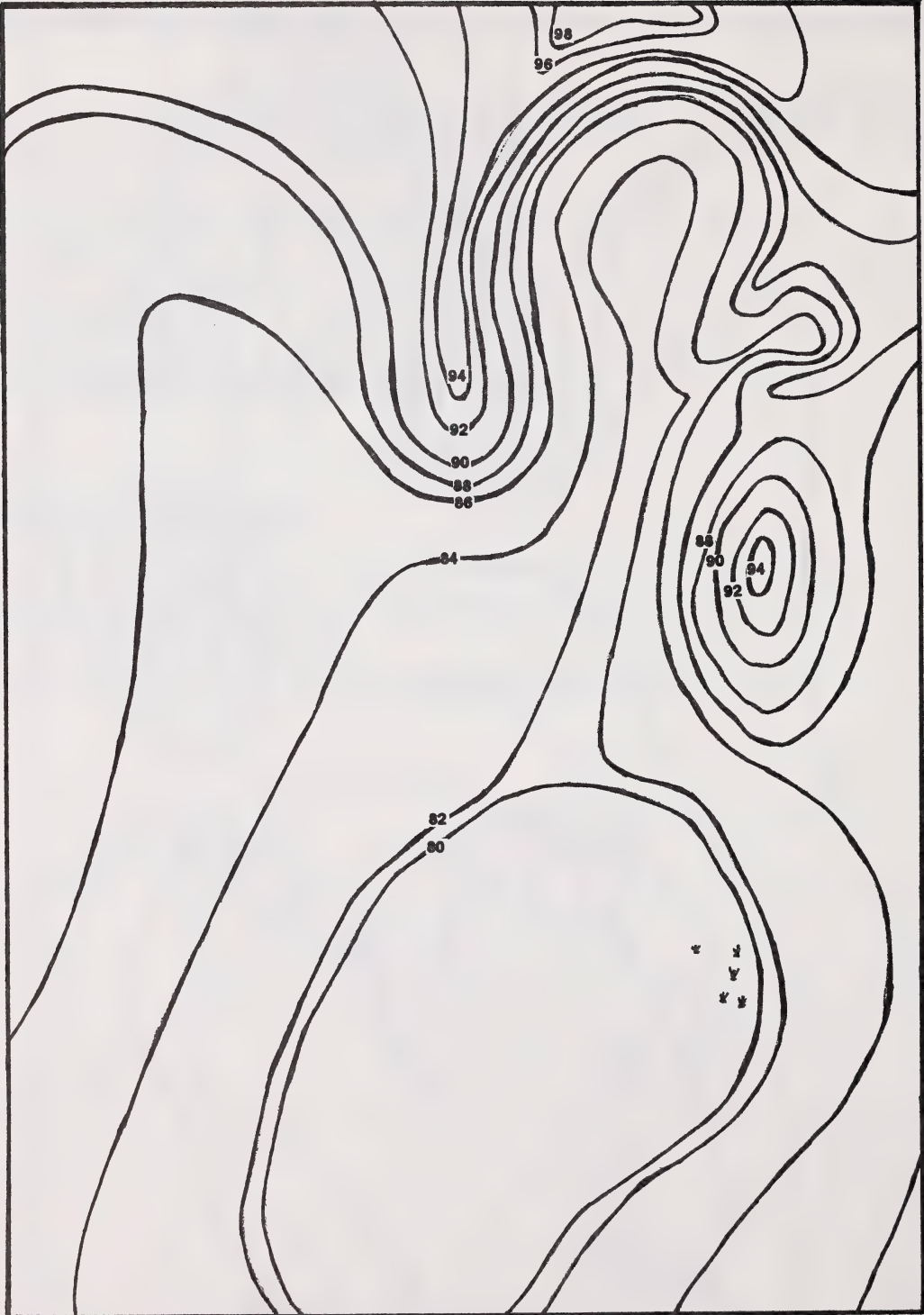


DATA SHEET ONE A



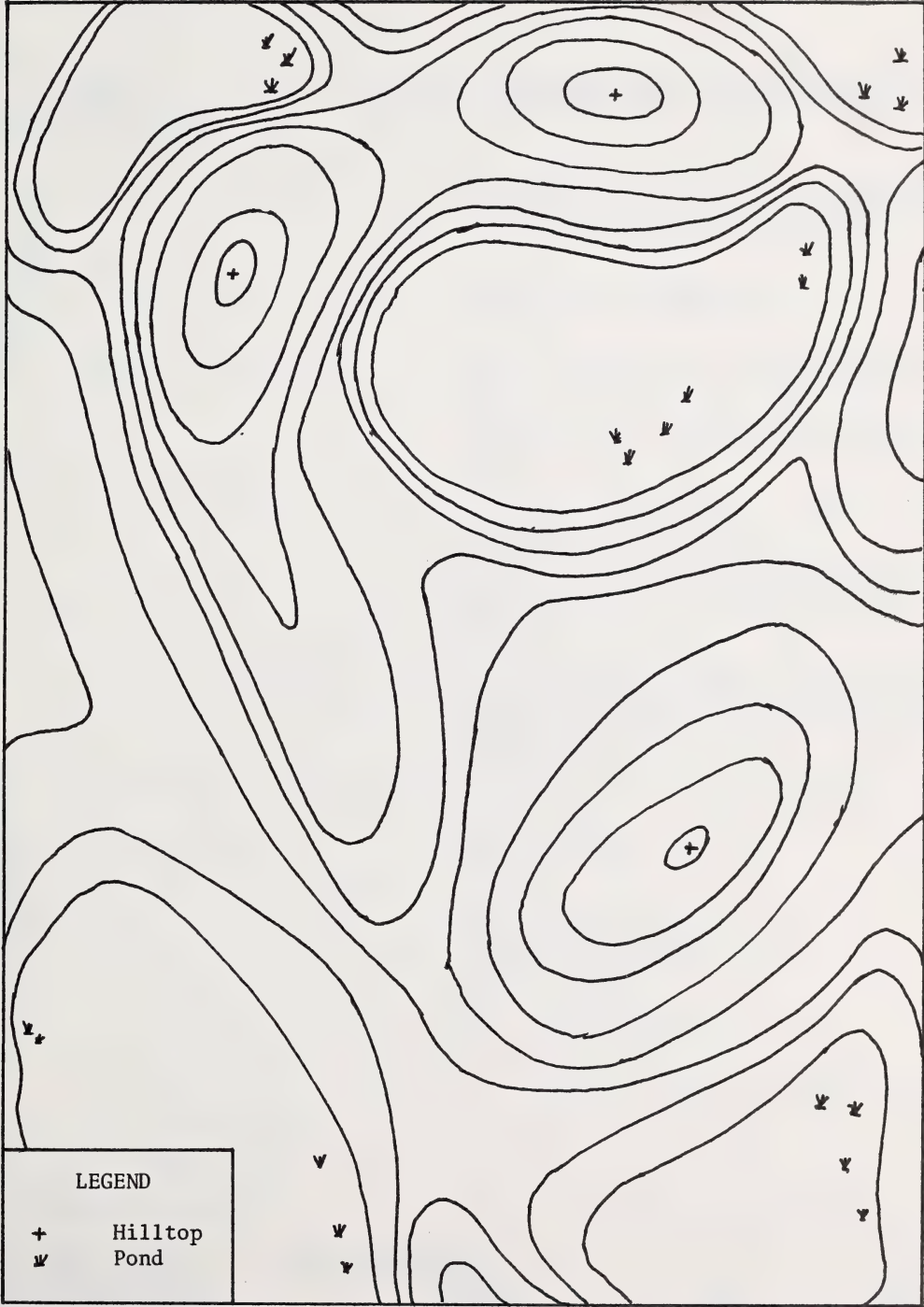
EXAMPLE 1a: Natural contours showing three unconnected sloughs.

DATA SHEET ONE B



EXAMPLE 1b: Modified contours showing upper sloughs drained into main storage pond.

TASK SHEET ONE



ACTIVITY 2

Got It Made In The Shade

Objective:

Students will investigate how soil reflectivity affects soil temperature and soil moisture retention.

Curriculum Fit:

Science 10, Unit III
Importance of Water

Science Concepts:

Water changes to various physical states within the hydrologic cycle. Science can account for many of the chemical and physical properties of water.

Skills:

Examine the effects of human behavior on the environment. Understand and apply data collection, organization and interpretation skills.

Attitudes:

Be aware of the need for trade-offs in order to arrive at workable situations involving science and technology in society.

Agriculture Concepts:

Dependence on Soil and Water

Cognitive Level:

Application

Materials Required:

Two trays of soil
Two light sources
Reflective mulch
Light meter
Soil moisture tester
Two thermometers

Time Required:

Two class periods, 24 hours apart.



BACKGROUND - For the Teacher

The critical factor controlling water supply to plants is the amount of water held in the soil. This can vary according to soil type, water supply, and evaporation rate.

Most farmers must accept their soil's water holding capacity as it is. Except in greenhouses and irrigated farms, the water supply is also beyond the producer's control. There are, however, several techniques that can limit soil evaporation.

In this activity your students will see and measure how a reflective mulch affects soil temperatures and soil evaporation.



PROCEDURE

Part 1

Preparation:

1. Prepare a soil mix using equal volumes of:
 - potting soil
 - peat moss
 - vermiculite, coarse sand or perlite
2. When mixed uniformly, divide the soil mix into two planting trays and level it.
3. Place a light source above each tray.

Part 2

Introduction:

4. Review the importance of soil water to plants. Explain that evaporation is an important factor in the water balance of soils, and that in this activity they will demonstrate a way of reducing evaporation.
5. Divide the class into two groups: Group One will set up and monitor the control tray, Group Two will set up and monitor the experimental tray.

Part 3

Activity:

Day 1

6. Distribute a copy of Task Sheet One to each working group. This has the set up directions for the experiment.
7. Allow students five minutes to read the sheet and assign tasks, then 20 minutes to complete the set up and to record starting conditions on Data Sheet One.
8. Inspect the control and experimental apparatus arrangements and records. Have each group turn on their light source.

Day 2

9. Have each group record the final temperature and final water content of their soil.

Part 4

Conclusion:

10. Lead a discussion that centers on the questions below.

DISCUSSION QUESTIONS

1. Do the soil temperatures and water contents differ in the two cases?
2. How can the difference (or lack of difference) be explained?
3. Are there uncontrolled variations affecting this experiment that cannot be assumed to be the same in the control and experimental cases?
4. Are there steps students would take to test or improve the research design of this experiment?
5. Assuming that a reflective mulch does conserve soil moisture, what are some reasons why a farmer in arid conditions should use it? Is the farmer obligated to use such a technique?

RELATED ACTIVITIES

1. Use several trays of soil mix and try a variety of soil covers.
2. Try planting some seedlings - do not add any more water to either tray. Which seedlings survive for the longest time before dying of drought?

Hint for Success:

Extend the survey time to obtain optimum results.



DATA SHEET ONE

TO BEGIN

1. Sprinkle water on your tray of soil until water runs out of the bottom.
2. When the water has stopped draining, measure the soil moisture level and record your reading on DATA SHEET ONE.
3. Measure the distance from the surface of your soil to the front of your light source.
4. Insert a thermometer 25mm into the soil and, after five minutes, record the soil temperature.
5. Turn on your light source and use an incident light meter to measure the amount of light striking your soil sample directly below the center of the light source. Record the reading on DATA SHEET ONE.
6. If the control and experimental samples do not receive the same amount of light, adjust the height of one source until light levels match. Turn off the light source. Record incident light level.
7. Experimental group: Apply a 10mm layer of the light colored mulch over your soil.
8. Both groups: Turn on light source and record the date and time of your start.
9. Both groups: Use a reflected light meter to measure the amount of light reflected. Record level on DATA SHEET ONE.

TO FINISH

10. Repeat all measurements and record the results in the FINAL STATE section of DATA SHEET ONE.



TASK SHEET ONE

INITIAL STATE

START TIME _____

DATE _____

SOIL TO LIGHT DISTANCE _____

INCIDENT LIGHT LEVEL _____

SOIL TEMPERATURE _____

SOIL MOISTURE LEVEL _____

REFLECTED LIGHT LEVEL _____

FINAL STATE

STOP TIME _____

DATE _____

SOIL TO LIGHT DISTANCE _____

INCIDENT LIGHT LEVEL _____

SOIL TEMPERATURE _____

SOIL MOISTURE LEVEL _____

REFLECTED LIGHT LEVEL _____

ACTIVITY 3



Keeping Warm By Freezing

Objective:

Students will experience a practical application of the latent heat of fusion and consider a similar effect of latent heat of vaporization.

Curriculum Fit:

Science 10, Unit III
Importance of Water

Science Concepts:

Water changes to various physical states within the hydrologic cycle. Science can account for many of the chemical and physical properties of water.

Skills:

Utilize and evaluate various approaches for assessing and solving problems.

Attitudes:

Understand that science and technology influence and are influenced by societal issues.

Agriculture Concepts:

Dependence on Soil and Water
Capital and Technology Intensity

Cognitive Level:

Application

Materials Required:

Refrigerator
Two growing potted plants of the same type
Spray bottle of water

Time Required:

20 minutes for instruction, a few seconds every half hour for one day, 30 minutes for evaluation and interpretation of results.



BACKGROUND - For the Teacher

In studying ecology and the water cycle students become aware of evaporation and freezing as aspects of water in the environment. In studying physics, students are taught that water absorbs or releases heat without changing temperature while it is changing between solid, liquid and gaseous phases. In this activity, students observe a practical use that agricultural producers make of this latent heat.

Frost protection is important to producers who grow crops near their limits of adaptability. It may also be critical to any farmer confronted with a freak weather event. Spraying water on plants can protect against frost damage in two ways, one of which is demonstrated here.

As water freezes (changes from liquid phase to solid phase) it releases heat. This heat can be absorbed by any material in contact. This principle can be used by fruit or vegetable growers to protect tender plants from mild frosts. As misted water freezes it releases its heat to the plants it is on and the farmer ends up with a coating of ice on an unfrozen plant. This is the effect to be illustrated here.

The other use of water is important in exceptionally early springs, where flower buds might break before the last frost of the winter. Water is sprayed on the plant throughout the day. As it evaporates (changes from liquid phase to gas phase) it absorbs heat from the plant and chills the buds enough to prevent flowering.

NOTE

To protect a plant from freezing it is essential that liquid water be freezing throughout the time that temperature is below 0°C. If the water on the experimental plant freezes completely, then the ice temperature can fall to air temperature. Adjust the spray schedule in step 10 to ensure that liquid water is always present.

PROCEDURE

Part 1

Preparation:

1. Obtain two healthy plants of the same type and approximately the same bushiness. If you grow your plants from seed begin at least a month before you want to run this experiment.
2. Set your refrigerator so that it will be about -2°C . (See Teacher's Sheet One for calibrating a refrigerator.)
3. Divide a shelf into two chambers with a plastic sheet. Label one side EXPERIMENT and the other CONTROL.
4. Install a thermometer in each growth chamber produced by the plastic divider.

Part 2

Introduction:

(Day 1)

5. Explain that students will be seeing a special effect produced by the unique properties of water.
6. Briefly describe the procedure of the experiment. Ask students to predict the result using Student Data Sheet One.
7. Have two students open the refrigerator and read the temperature in each growth chamber.

Part 3

Activity:

(Day 1)

8. Have two other students each place one plant in one chamber.
9. Spray the experimental plant with water to the dripping point and close the refrigerator.

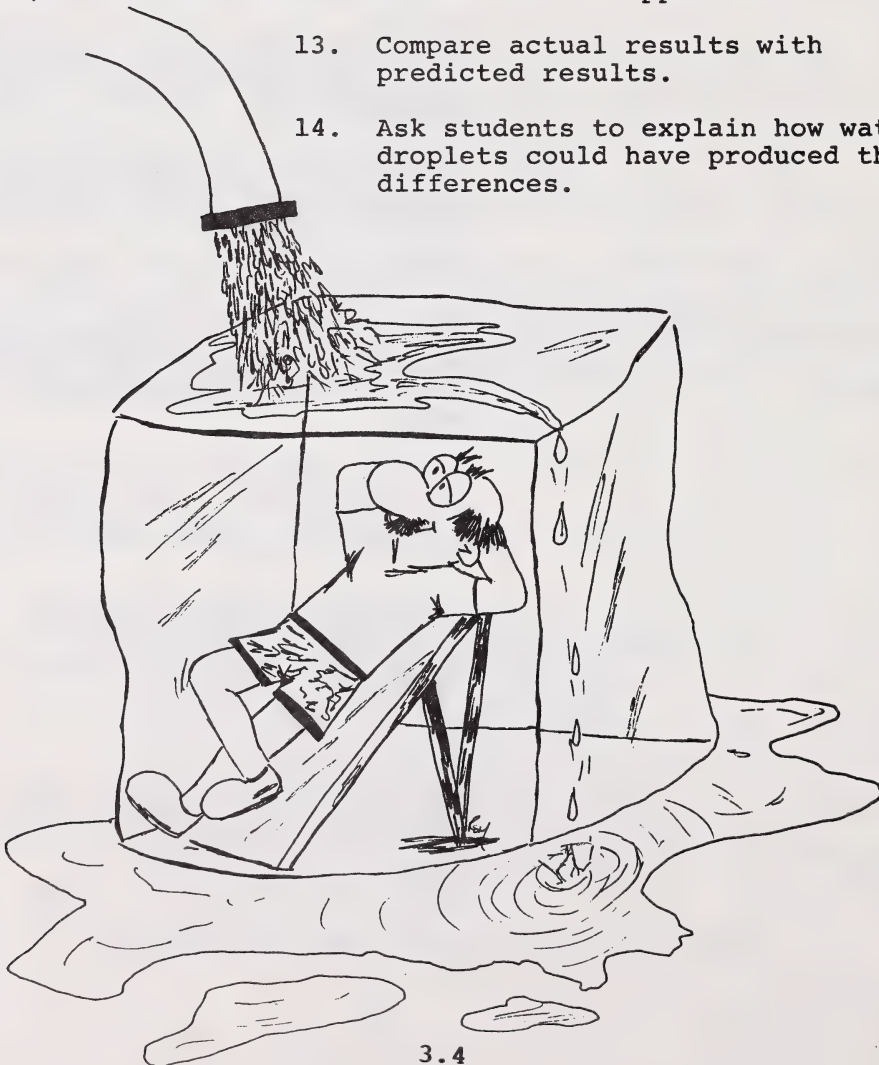
10. Each half hour throughout the day spray the experimental plant to the dripping point. At each spraying note any changes to the plants.
11. At the end of the school day remove the plants from the growth chambers and record their physical appearances.

Part 4

Conclusion:

(Day 2)

12. Have students inspect the two plants and identify any differences in appearance.
13. Compare actual results with predicted results.
14. Ask students to explain how water droplets could have produced the differences.



DISCUSSION QUESTIONS

1. What are some other ways that people protect plants from frost?
2. If you were a farmer, how would you decide:
 - a. whether to protect crops against an early frost?
 - b. which method to use for frost protection?
3. Why might you choose to grow a frost tender crop in preference to one that is known to be hardy where you live?

RELATED ACTIVITIES

1. Design and conduct an experiment to delay bud development by cooling twigs with evaporation.
2. Tour a greenhouse development to learn about season-stretching activities.
3. Identify crops that have been grown in special circumstances (microclimates) near your home even though they are known to not be hardy there.





TEACHER'S SHEET ONE

Calibrating Your Refrigerator

To perform a frost-tolerance experiment with a refrigerator you must know what temperature results from every thermostat setting and whether all parts of the refrigerator interior are the same temperature.

You can do this calibration yourself or have students do it.

1. Place thermometers in the refrigerator on each side of the top shelf and each side of the bottom shelf.
2. Set the refrigerator thermostat at its warmest setting.
3. Allow one hour for the refrigerator to reach the set temperature.
4. Open the door and read the four thermometers (**WARNING:** The interior will immediately begin to warm up. Be quick!).
5. Reset the thermostat one step cooler.
6. Repeat steps 3 to 5 until you have gone to the coldest setting.



STUDENT DATA SHEET ONE

A. PREDICTED RESULT

B. OBSERVED RESULT

C. EXPLANATION OF OBSERVATIONS

ACTIVITY 4



Why Can't A Person Be More Like A Cow?

Objectives:

Students will compare the processes and organs of digestion in humans and ruminants, and compare them in terms of energy input, conversion and output.

Curriculum Fit:

Science 10, Unit IV
Personal Energy Systems

Science Concepts:

Energy systems can be organized into input, conversion and output. Energy can be measured in quantitative terms. Efficiency of an energy system can be calculated.

Skills:

Preparation of systems diagrams.

Attitudes:

Responsibility regarding consumption for personal needs.

Agriculture Concepts:

Production, Processing and Distribution System
Diversity

Cognitive Level:

Application, Analysis

Materials Required:

Information is all included
Overhead projector (optional)

Time Required:

One class period



BACKGROUND - For the Teacher

One of the most important forms of the potential energy stored in chemical bonds is food energy. Living things release this energy through the oxidation processes of metabolism. Large animals must precede these oxidations by modifying their food through digestion.

Many of your students will already know, and all will recognize, that cattle obtain all of their energy and nutrients from cellulose-based foods while we require a wider variety of foods for nutrients and get very little food energy from cellulose. This observation can only be explained by analyzing how each digestive system deals with food.

In this activity your students compare the digestive anatomy and processes of beef cattle to those of humans. They will convert prose statements describing each stage of the process into one-step system flow diagrams, and describe the entire process in terms of energy inputs, conversions and outputs. Finally, they develop an efficient food web to transfer energy.

SPECIAL NOTE

The film *Sunchangers* is an excellent outside resource for this lesson. You can obtain it from the Alberta Agriculture Film Library at the address shown in the introduction. The order number is 400-09.

PROCEDURE

Part 1

Preparation:

1. Photocopy the data sheets as handouts or overhead projector slides. Compare the data sheet information to the explanations on Teacher Reference One.
2. Make a photocopy for handout of each of the seven task sheets.

Part 2

Introduction:

3. Using the Data Sheets One and Two, and the information in Teacher Reference One, explain the basis of system flow diagramming to the class.
4. Divide the class evenly into 7 working groups and give one of the task sheets to each group.

Part 3

Activity:

5. Each group is to convert the written statement on their task sheet into a flowchart of one step in digestion.

NOTE

Groups 1, 5, 6, 7 all have a step in ruminant digestion and its equivalent in humans. They should do these diagrams on two separate sheets.

6. Beginning with group one, have each group in turn explain their step and post their flowchart.

NOTE

Charts should be posted in two vertical rows, one for cattle digestion and one for human digestion.

Part 4

Conclusion:

7. When both processes are posted analyse them in terms of what forms of input energy are present, what transformations take place and what forms of output energy remain.
8. Have each student diagram a food web that makes the most efficient use of the energy and nutrients in the following organisms:

grass hay	oats
peas (seeds & vines)	wheat
cattle	people
decomposers	lettuce



DISCUSSION QUESTIONS

1. From the information in the flowcharts, why do people call the cow's abomasum the "true stomach"?
2. What organisms besides cattle use symbiotic bacteria to digest cellulose?
3. How can humans most easily obtain the nutrient energy contained in cellulose?
4. In fact, beef cattle today are rarely butchered until they have been fed energy-rich and protein-rich grains or silage for several months. What is the purpose of this special feeding, and how does it affect the efficiency of the food web you developed above?

RELATED ACTIVITIES

1. Imagine and flowchart an industrial process to convert woodchips and straw into edible crackers or paste for humans. Survey the class or the school to see who would eat such a product.
2. Find out the amount of energy in 100 grams of cellulose, starch, protein and beef fat. What percent of this energy can be extracted by a) cattle and b) humans?
3. Expand the overall flowcharts horizontally to show the energy inputs, transformations and outputs from absorption and cellular metabolism.



TEACHER'S SHEET ONE



SYSTEMS ANALYSIS

As each field of science has become more specialized and less accessible to non-experts, scientists have searched for ways to communicate their knowledge clearly and simply. One method they have developed is systems analysis and the system flow chart.

Systems analysis depends on the principle that non-experts can make many decisions and take actions based on them, without knowing the details of a process if they monitor the inputs and outputs of the process. Normally a generalist or layperson would deal with the overall system while a specialist would concentrate on analysing the sub-system making up a single step. Thus a beef feeder can function with the overall flowchart that starts Data Sheet Two, a nutritionist would concentrate on special features in the sub-system for FOOD, a physiologist would investigate the sub-system BODY PROCESSES and so on.

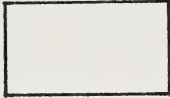
You need to be aware of one major simplification made for this activity. The six basic symbols shown in Data Sheet One each represent a class of symbols: advanced systems analysts use any of several variations. These special purpose symbols are not needed for an understanding of the power of flow charts and systems analysis.

DATA SHEET ONE



SYSTEM FLOW CHART BASICS

1. There are six basic symbols to use:



PROCESS
any operation
or function



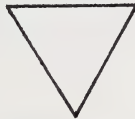
INPUT/OUTPUT
something ready
to enter the
system or some-
thing produced
by the system



FLAG
a place to add
extra notes,
comments or
explanations



DECISION
a point where
two alternate
paths can be
taken



STORAGE
a place where ma-
terial or data can
be put and be re-
claimed later



CONNECTOR
a coded indica-
tor that the line
you are on con-
tinues elsewhere.
The pickup point
will have the
same indicator.

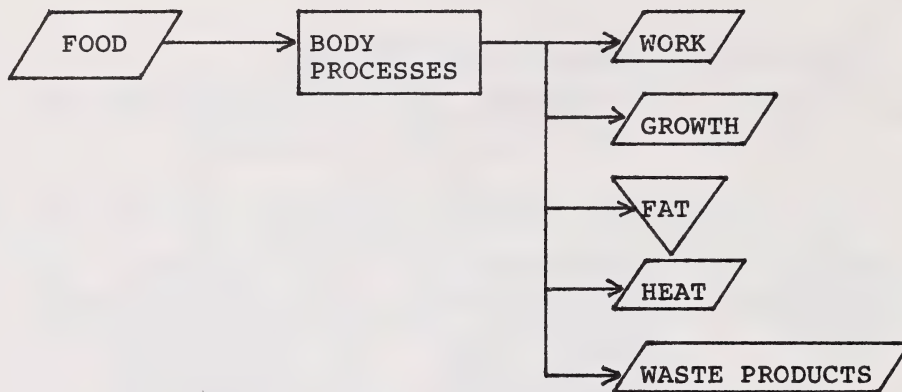
2. These six symbols are connected with flowlines
() that indicate movement through the
system.

Flow is usually from page top down and from left to
right.

DATA SHEET TWO



SYMBOLS AT WORK



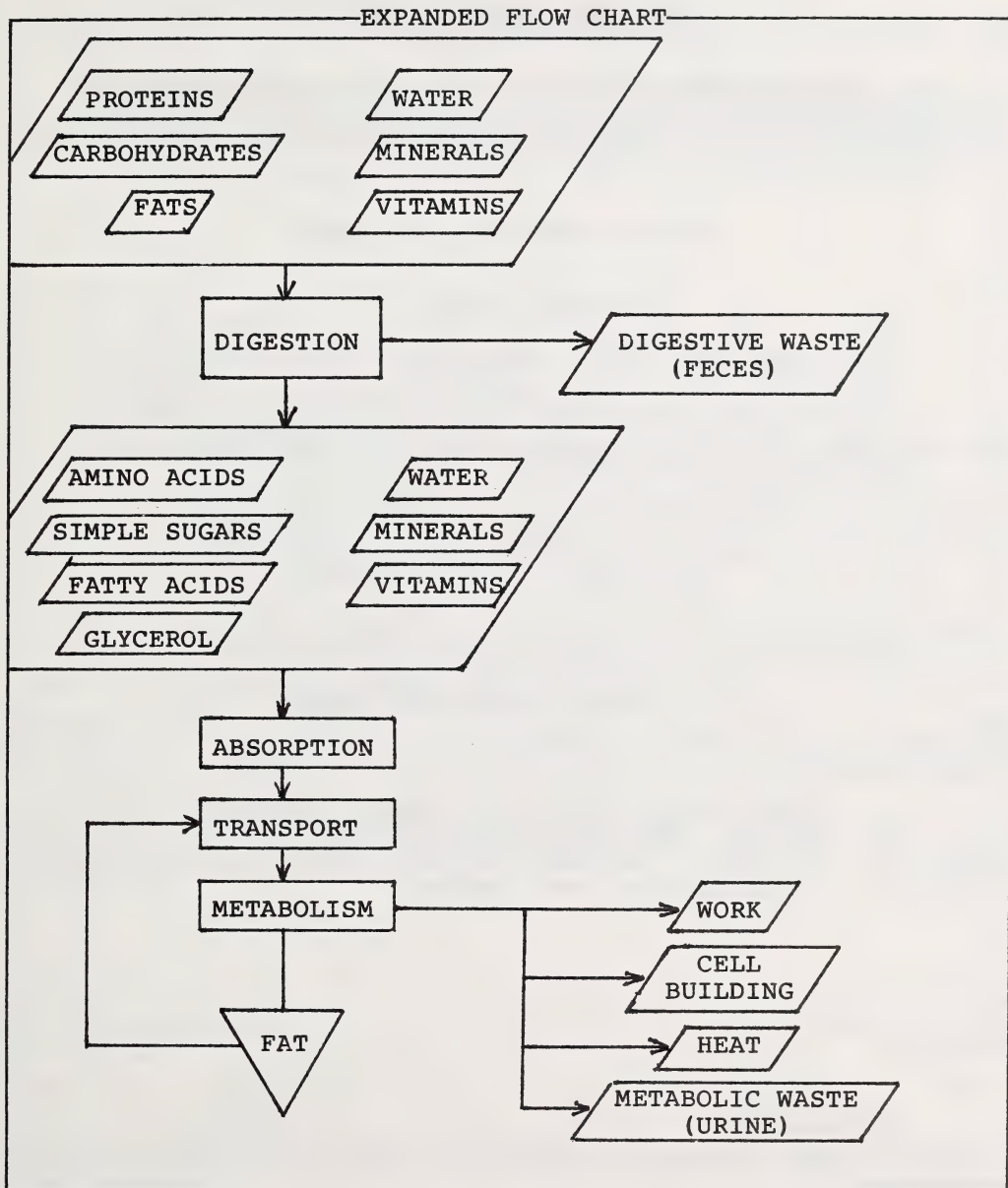
This simple chart shows how animals stay alive.

Food is an input.

The food is transformed in a set of body processes, which are not specified.

There are four irreversible outputs plus a storage point from which energy can be returned to the body processes.

DATA SHEET THREE





TASK SHEET ONE

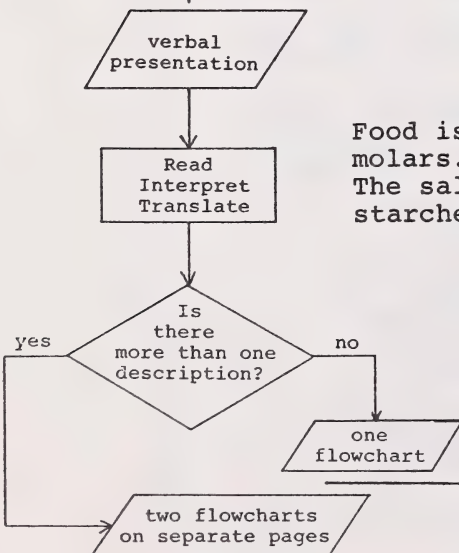
Your task in this activity is to convert the digestive step described below into a one-step system flow chart. If there are two similar processes described, do them on separate pieces of paper.

MOUTH DIGESTION (RUMINANT)

Grass is cut with the incisor teeth, mixed with saliva and swallowed, travelling to the rumen or first stomach. Later, swallowed grass is regurgitated as cuds (balls of food) and ground by the molars into finer particles. The chewed cuds are returned to the rumen.

MOUTH DIGESTION (HUMAN)

Food is cut by the incisors and ground by the molars. During grinding it is mixed with saliva. The saliva contains amylase which begins to break starches down into sugars.





TASK SHEET TWO

Your task in this activity is to convert the digestive step described below into a one-step system flow chart. If there are two similar processes described, do them on separate pieces of paper.

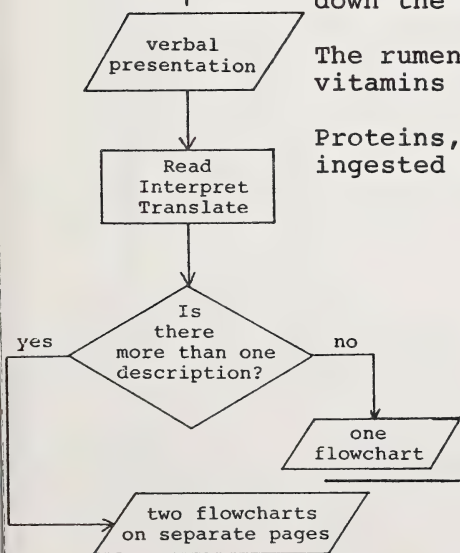
RUMEN DIGESTION

The first stomach or rumen is the home for colonies of microorganisms that are able to break down cellulose molecules. These are broken down to starches, then to sugars and then to very simple fatty acids. The acids are absorbed into the bloodstream for use in the cells.

Dietary protein or urea is converted into microbial protein; and as the microbes die they are moved down the system for digestion later.

The rumen bacteria produce Vitamin K and B-complex vitamins which are absorbed into the bloodstream.

Proteins, fats, lignin and about one half of ingested cellulose is passed on down the system.



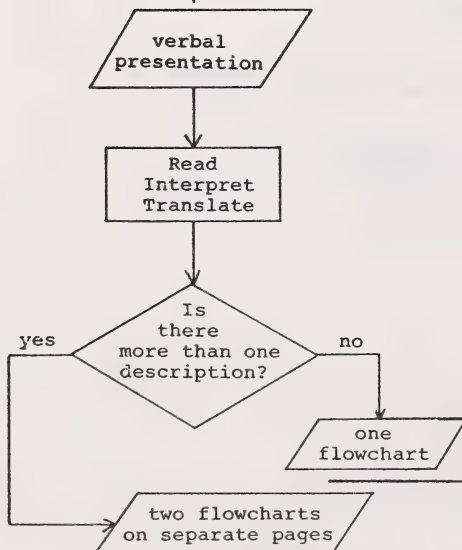


TASK SHEET THREE

Your task in this activity is to convert the digestive step described below into a one-step system flow chart. If there are two similar processes described, do them on separate pieces of paper.

RETICULUM DIGESTION

The main function of the second stomach or reticulum is to screen foods by size. It continuously contracts in a way that separates large food particles from small ones, and it periodically forces large particles back into the rumen and passes small particles on into the omasum or third stomach.





TASK SHEET FOUR

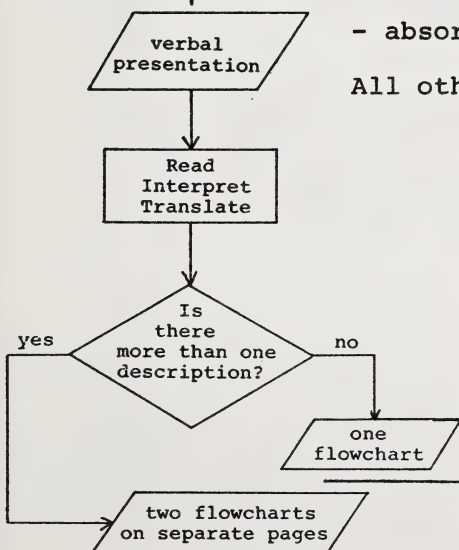
Your task in this activity is to convert the digestive step described below into a one-step system flow chart. If there are two similar processes described, do them on separate pieces of paper.

OMASUM DIGESTION

Animal scientists have found the third stomach or omasum very difficult to study. They have identified three probable functions:

- absorption of water into the bloodstream
- absorption of fatty acids
- absorption of the mineral magnesium

All other contents are moved on to the abomasum.





TASK SHEET FIVE

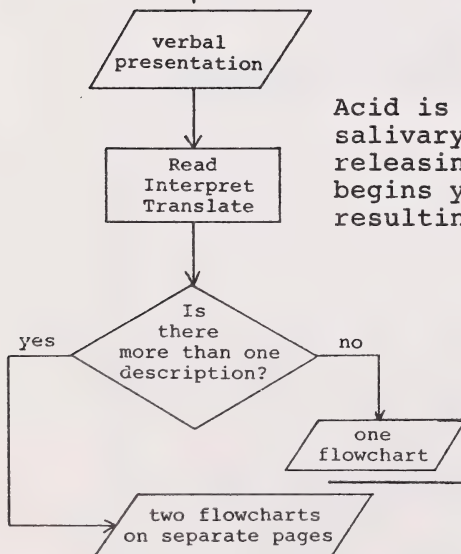
Your task in this activity is to convert the digestive step described below into a one-step system flow chart. If there are two similar processes described, do them on separate pieces of paper.

ABOMASUM DIGESTION (RUMINANTS)

Acid and protein digesting enzymes are added; proteins begin to break down releasing amino acids. Water is added to the mixture. Fats and carbohydrates are not digested. The resulting mixture passes to the small intestine.

STOMACH DIGESTION (HUMANS)

Acid is added to the mix, stopping the action of salivary amylase. Protein digestion begins, releasing protein fragments. Some fat digestion begins yielding fatty acids and glycerol. The resulting mixture passes to the small intestine.





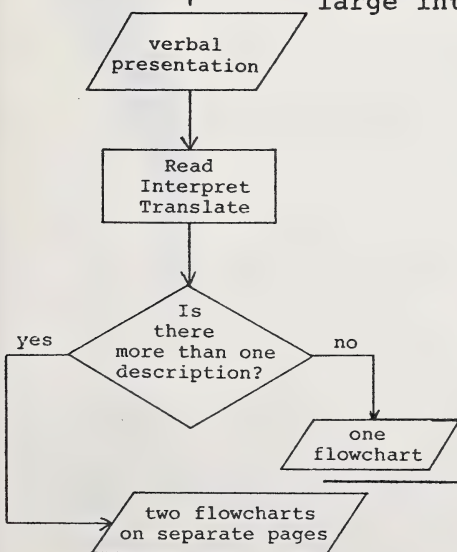
TASK SHEET SIX

Your task in this activity is to convert the digestive step described below into a one-step system flow chart. If there are two similar processes described, do them on separate pieces of paper.

SMALL INTESTINE DIGESTION (BOTH RUMINANTS AND HUMANS)

Bile and lipase digest fats, producing fatty acids, glycerol and emulsified fats. Protein and protein fragments are broken down into amino acids. Starches and double sugars are broken down into single sugars.

All 5 products above are absorbed into the bloodstream. Undigested materials are moved on to the large intestine.



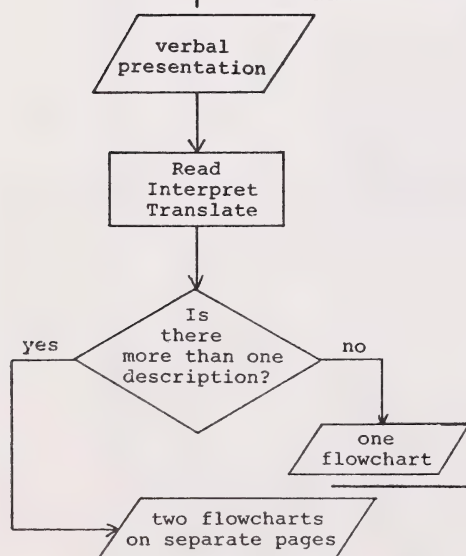


TASK SHEET SEVEN

Your task in this activity is to convert the digestive step described below into a one-step system flow chart. If there are two similar processes described, do them on separate pieces of paper.

LARGE INTESTINE DIGESTION (RUMINANTS AND HUMANS)

Water is absorbed into the bloodstream. Bacterial action converts undigestible material into feces. During feces formation, vitamin K is produced in humans and is absorbed into the bloodstream. Feces are excreted through the anus.



ACTIVITY 5

So How Good Is It Really?

Objective:

Students will develop a grid chart and use it to evaluate an agricultural product.

Curriculum Fit:

Science 10, Unit V
Product Evaluation

Science Concepts:

Consumer products have many characteristics that can be scientifically investigated.
Data are more meaningful when organized.

Skills:

Construct meaningful communications and analyse the communications of others.
Understand the relationship between expectations of consumers and responsibilities of producers.

Attitudes:

Appreciate the effects of advertising and mass media on consumerism.
Appreciate the usefulness of problem solving skills.

Agriculture Concepts:

Diversity
Production, Processing and
Distribution System

Cognitive Level:

Analysis, Synthesis, Evaluation

Materials Needed:

Included

Time Needed:

One hour



BACKGROUND - For the Teacher

Two types of information are needed to evaluate consumer products. The evaluator must know what functions the product is to fulfil and what characteristics the product has.

By listing the product requirements at the head of vertical columns and the product characteristics at the beginning of horizontal rows, a tester establishes an evaluation grid.

		REQUIREMENTS					
		1.	2.	3.	4.	5.	6.
C H A R A C T E R I S T I C S	1.						
	2.						
	3.						
	4.						
	5.						
	6.						

The tester can then consider each product requirement in turn and identify whether any characteristic satisfies it. After completing this matching process, the tester can rate the product on the basis of how many requirements it fills.

Evaluation grids can be made more discriminating by identifying degrees of satisfaction within a cell where a requirement is only partly met. In evaluating some products, specific tests may be required to determine whether a requirement has been satisfied.

PROCEDURE

Part 1

Preparation:

1. Photocopy DATA SHEET ONE.
2. Choose an object in your classroom that can be used for a sample brainstorm.

Part 2

Introduction:

3. Conduct a practise exercise in product analysis with the entire class.
 - a. Identify the sample product.
 - b. Ask students to list the working parts of the product. Record the list for the class.
 - c. Ask students to describe the function of the product, and to break that function down into simple sub-steps.
 - d. Show how the two lists can be arranged on two sides of a square to form a grid. (see BACKGROUND)
 - e. For each requirement listed across the grid, work down the column and identify which part fulfils that function.

Part 3

Activity:

4. Divide the class into working groups of four.
5. Have each group select a product to evaluate. This step will be most valuable if product selection is random.

6. Allow the groups 5 minutes to develop a preliminary list of product characteristics and another 5 minutes to list functional sub-steps.
 - If students need to do research into either aspect of the product have them specify where they would look for the information.
7. Have each group construct a display grid using the lists they developed in class and mark the cells that match a particular characteristic with the function it performs.

Part 4

Conclusion:

8. Ask each working group to present their analysis orally to the other groups.

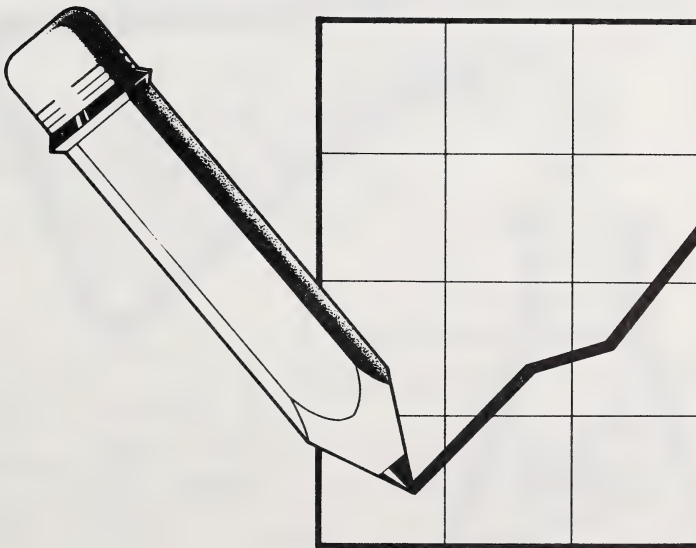


DISCUSSION QUESTIONS

1. Are there any cells where a test or experiment is necessary to show whether a function is performed?
2. How could this checklist procedure be used to do comparative evaluations of similar products?
3. How could this procedure be modified to show partial meeting of a requirement?

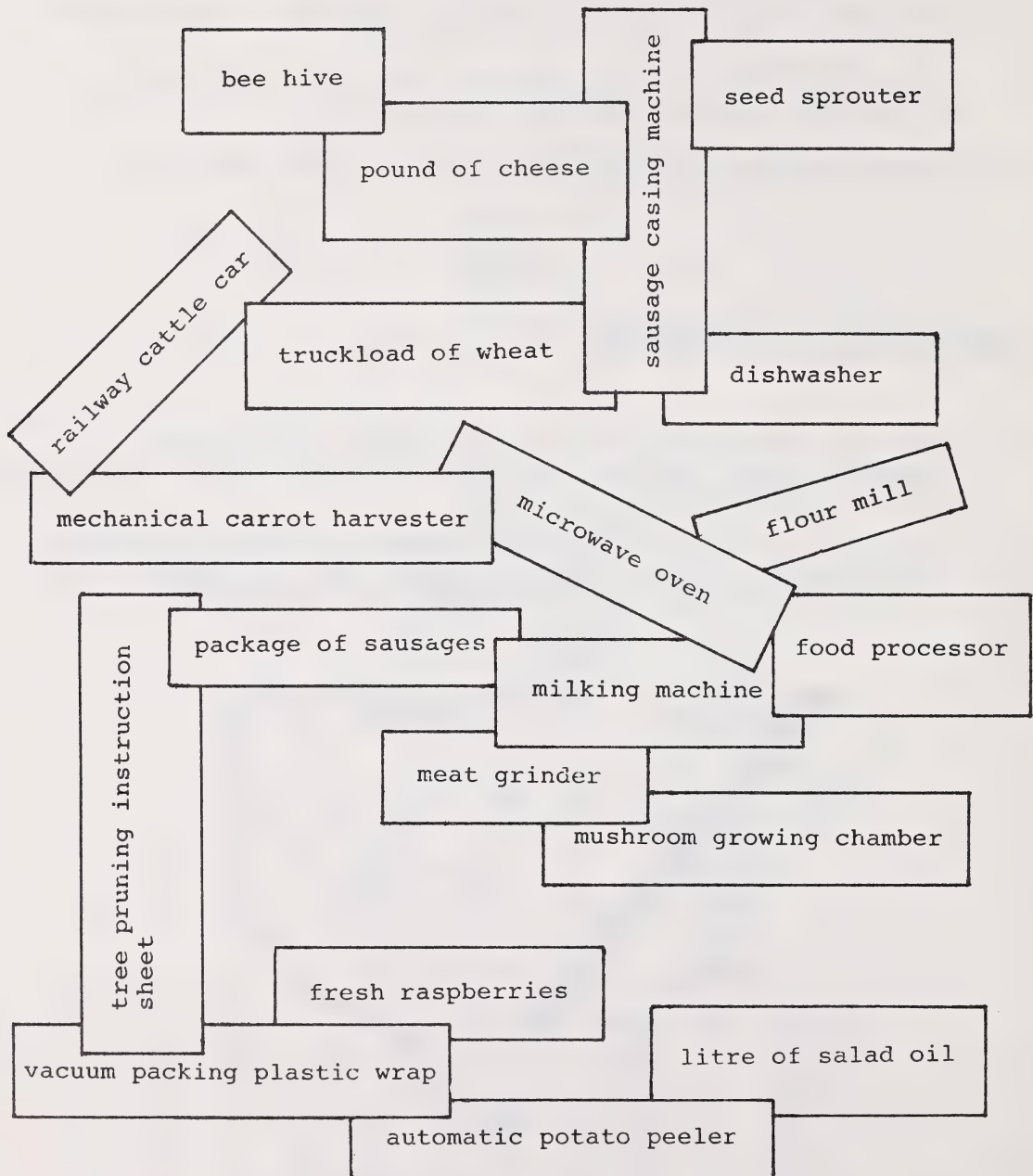
RELATED ACTIVITIES

1. Review several copies of Consumer Report or Canadian Consumer to see how the contributors organize their product evaluations.
2. Inquire with Health and Welfare Canada or Alberta Consumer and Corporate Affairs about how food, food processing, and food sales standards are established and monitored.



DATA SHEET ONE

PRODUCTS TO EVALUATE



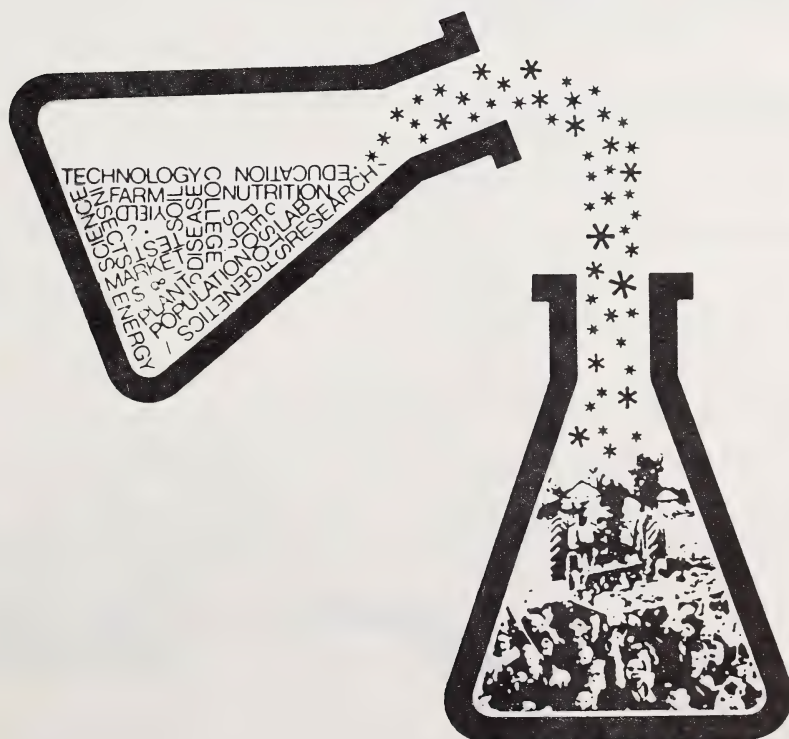
SECTION B: SCIENCE 20

The topics chosen for Science 20 have led us to concentrate our lessons on Unit II: Biochemical Applications and Unit III: Biomass Energy.

The various issues of food production and storage are of course the eternal business of agriculture. In modern times the application of biotechnology to these matters has become the dominant practical, social and ethical issue at all levels of the industry. Therefore two of our lessons address Unit II.

Lesson Six deals with food preservation. In this lesson students investigate the keeping qualities of a food sample using various simple preservatives. In Lesson Seven students confront the choices that commercial food producers must make among herbicides with varying characteristics.

Energy systems are critical to food production and processing, so lessons Eight and Nine look at their technologies. In Activity Eight students calculate the biogas yield possible from several typical farm production systems. In Activity Nine they consider the making of fuel ethanol as an end use for farm produce.



ACTIVITY 6

Moldilox and the Five Pairs



Objectives:

Students will demonstrate that food spoilage can be prevented by the action of several common, household substances.

Curriculum Fit:

Science 20, Unit II
Biochemical Applications

Science Concepts:

Biologically related technologies, such as food production and preservation, directly improve the quality of life.

Food preservation techniques keep food from spoiling.

Skills:

Apply data collection, organization and interpretation skills.
Use controlled experimentation.

Attitudes:

Appreciate the variety of factors that relate to the success of a given technological process.

Agriculture Concepts:

Capital and a Technology Intensity
Diversity

Cognitive Level:

Application

Materials Required:

one loaf of preservative-free bread
salt
sugar
a mild organic acid: e.g. acetic (vinegar), citric, malic, sorbic, benzoic
10 Petri dishes or similar containers

Time Required:

One 50 minute period for introduction and setup

Five minutes daily to monitor changes

One 50 minute period for results and conclusions



BACKGROUND - For the Teacher

Food spoilage is generally a matter of micro organisms digesting our food before we can. These micro organisms may be bacteria (e.g. Salmonella spp or Clostridium botulinum) or fungi. In either case, the spoiling organisms typically travel as airborne spores which will develop on any food supply that includes available water.

Most historical food preservation methods depend on removing water from a food or binding to it in a way that makes it unavailable. Freezing, drying, pickling and salting all work on this water blocking principle.

In this lesson your students will see how long mold growth can be inhibited on bread using several of these ancient techniques. With the preservatives chosen students can also experience the changes in taste that these chemicals produce. Most of current food preservation research is devoted to developing substances that inhibit mold growth without affecting taste or human health.



PROCEDURE

Part 1

Preparation:

1. Purchase or prepare a supply of preservative-free bread. If you cannot find this commercially available, pancakes will work well.
2. Prepare a cupboard or box for use as a growth chamber. Your chamber will need to be room temperature, dark and exposed to normal air.
3. Photocopy the data and task sheets so that groups can have one copy of each data sheet and four copies of Task Sheet One.

Part 2

Introduction:

4. Explain the nature of the experiment to be done.
5. Divide the class evenly into five working groups. Each will be responsible for one of the parallel experiments.
6. Distribute Data Sheet One: Initial Conditions to the groups. Have them highlight the particular experiment they are going to perform.

Part 3

Activity:

7. Have representatives of the groups gather the materials and reagents for their experiment.
8. Distribute Data Sheet Two: Setting Up. Students should set up their experiments following the directions.
9. When all experiments are begun distribute 4 copies of Task Sheet One: OBSERVATIONS to each group.

10. A member of each group will have to monitor control and experiment daily, recording changes on the sheet. Continue recording for a full week; if mold development is not significant then extend observation period.

Part 4

Conclusion:

11. Have each group report their results.
12. For each group record
 - a. when mold appeared on the control sample
 - b. if the experimental sample developed mold and when
 - c. any special taste or odor associated with their preservation technique
13. Have the class decide which preservative was most effective in preventing mold.



DISCUSSION QUESTIONS

1. Why might control samples vary between experiments in time to start of mold?
2. What was the first evidence of mold growth?
3. If all bread were sold without preservatives, how would it affect:
 - a. the price of bread?
 - b. the amount of bread available?
 - c. people's bread buying habits?

RELATED ACTIVITIES

1. Have students view each type of mold microscopically, draw them and attempt to identify them using a key.
2. Have students research and report on irradiation, vacuum packing, canning and inert gas packaging as preservation techniques.
3. Have students identify the preserving agent in a variety of foods at home. Investigate the structure and mode of activity for each.
4. Organize an in-class debate on the resolution "that food preservation by irradiation should be approved in Canada immediately".

DATA SHEET ONE : INITIAL CONDITIONS



CONTROL

- bread as bought
- in open dish
- in growth chamber

EXPERIMENT

- bread dried until crisp
- in open dish
- in growth chamber

CONTROL

- bread as bought
- in open dish
- in growth chamber

EXPERIMENT

- bread heavily salted on all surfaces
- in open dish
- in growth chamber

EXPERIMENT

- bread as bought
- in open dish
- in refrigerator

CONTROL

- bread as bought
- in open dish
- in growth chamber

EXPERIMENT

- bread heavily sugared on all surfaces
- in open dish
- in growth chamber

CONTROL

- bread as bought
- in open dish
- in growth chamber

CONTROL

- bread as bought
- in open dish
- in growth chamber

EXPERIMENT

- bread coated with the acidin supplied
- in open dish
- in growth chamber

DATA SHEET TWO: SETTING UP



DRYING METHOD

You can dry your bread in any of several ways: in a warm oven, on a rack in a sunny window, on a rack over a hot air register. Whichever you choose, continue until the bread is crisp.

SALTING AND SUGARING METHOD

Sprinkle salt or sugar on the upper surface of the bread until grains remain visible on surface. Let stand for five minutes. Turn slice over so that excess is caught in the holding dish and repeat on second side.

ACID (Pickling) METHOD

If acid is in liquid form, use an atomizer and spray it lightly on each surface. Repeat the spraying as soon as the moisture disappears.
Continue for 20 minutes.

REFRIGERATION METHOD

Place the dish containing the experimental sample in the laboratory refrigerator.



TASK SHEET ONE : OBSERVATIONS

Days after set-up: _____

Visible Conditions

CONTROL

EXPERIMENT

Odor

CONTROL

EXPERIMENT

OTHER DATA

CONTROL

EXPERIMENT

Days after set-up: _____

Visible Condition

CONTROL

EXPERIMENT

Odor

CONTROL

EXPERIMENT

OTHER DATA

CONTROL

EXPERIMENT

ACTIVITY 7



Helping the Herbicide Handler's Headaches

Objective:	Students will consider four typical herbicides with notably different performance characteristics, and identify situations that would favor one or another.
Curriculum Fit:	Science 20, Unit II Biochemical Applications
Science Concepts:	Understand how crop yields can be maximized by use of technologies designed to maximize production.
Skills:	Use appropriate strategies in problem solving.
Attitudes:	Appreciate the variety of factors that relate to the success of a given technological process.
Agriculture Concepts:	Diversity Technology and Capital Intensity
Cognitive Level:	Evaluation
Materials Required:	Included
Time Required:	One hour



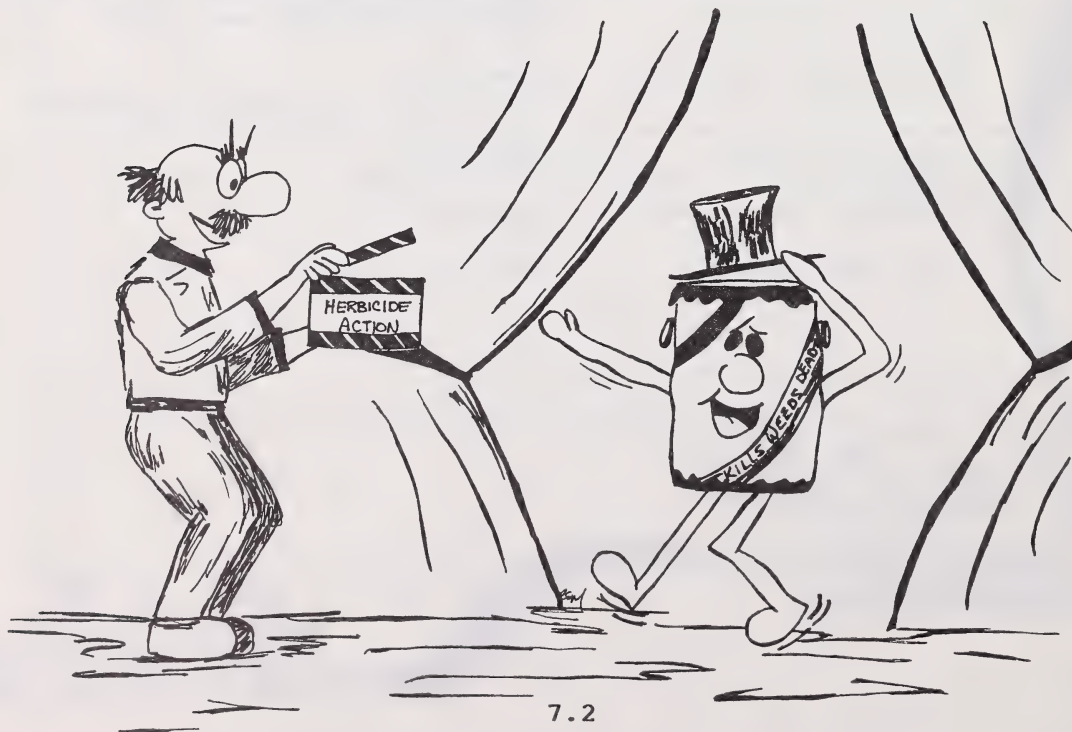
BACKGROUND - For the Teacher

Weed control is an important factor in maximizing crop yields. Weeds compete with crop plants for water, soil nutrients and light throughout the growing season. If harvested with a crop they also reduce yield by reducing the per cent of desirable material (e.g. grain seed, edible forage).

At one time cultivation of the soil was the main technique for controlling weeds. In some situations (home gardens, flower beds) it still is, but in the late 1940's weed killing chemicals (herbicides) became available to farm producers as an alternative control. At present, economic pressures toward large scale production, minimum labor costs and reduced tillage to prevent soil erosion all encourage farmers to depend on herbicides for controlling weeds.

Their popularity has led to extensive research into specialized herbicides. Today there are herbicides that are specific to single species, to entire plant classes or that kill all plants. The chemicals also vary in their stability, hazard to animals, ease of use and cost.

In this activity your students begin with a problem weed situation and the descriptions of four herbicides. Their job is to recommend a weed control procedure that will be effective, be cost efficient and minimize danger to non-target organisms (including spray operators and consumers).



PROCEDURE

Part 1

Preparation:

1. Make one copy of Data Sheet One and Task Sheet One for each working group you will use.
2. Make one copy each of Data Sheets Two through Four.
3. Cut out the two weed problem cards from each of the later data sheets.

Part 2

Introduction:

4. Divide the class into six working groups and give each group a copy of Data Sheet One and Task Sheet One.
5. Explain that each group is to apply one or more of the herbicide choices from Data Sheet One to a weed problem.
6. Have one member of each group choose a weed problem card.

Part 3

Activity:

7. Allow the groups five minutes to review their weed problem and develop a control strategy.
8. After five minutes have the groups report their recommendations and the rationale for them. Allow five to seven minutes per group, including questions.

Part 4

Conclusion:

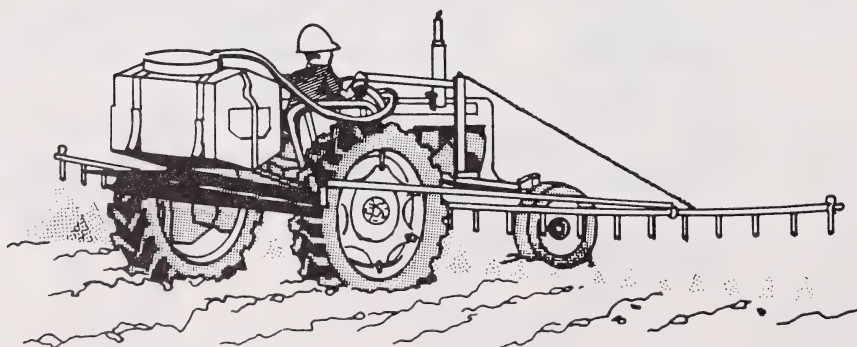
9. Lead a class discussion on herbicides and non-chemical weed control based on the questions below.

DISCUSSION QUESTIONS

1. What factors must be considered in selecting herbicides for a commercial venture?
2. What environmental concerns do students have about herbicide use?
3. If students were employed to apply the herbicides described, what safety equipment would they want to have available?
4. Where can students look for information on herbicide effectiveness, environmental implications, health hazards to applicators and consumers?
5. How can information available to the public on complex scientific issues with high emotional impacts be evaluated?

RELATED ACTIVITIES

1. Stage a debate on chemical or non-chemical control of weeds in commercial crops.
2. Invite a guest speaker to address the class on herbicide issues.
3. Monitor news media for coverage of herbicide issues.



DATA SHEET ONE



Herbicide W 1. Toxic to all plants. 2. Absorbed through leaf and stem surfaces. Migrates to the roots. 3. Breaks down in soil within 3 days. 4. Very low toxicity to animals.	Herbicide X 1. Toxic to all plants. 2. Absorbed by roots. 3. Will persist in soil for up to three years. 4. High toxicity to mammals, low toxicity to birds and fish.
Herbicide Y 1. Toxic to broad leaved plants only. 2. Absorbed through leaf surface and moves throughout the plant. 3. Breaks down in soil within 14 days. 4. Low toxicity to mammals.	Herbicide Z 1. Toxic to plants in the grass family. 2. Absorbed by leaf and stem surfaces. 3. Persists in soil for one growing season. 4. Moderate toxicity to mammals.



DATA SHEET TWO

WEED PROBLEM ONE

You have decided to convert an area near your machine sheds from a low maintenance, grassed lawn to a plant free, gravelled pad for fuelling and maintaining vehicles. You wish to kill the plants presently growing there and prevent regrowth for as long as possible.

WEED PROBLEM TWO

You are seeding a new variety of grain into a field that you cropped last year. You want to kill all early spring weeds and any resprouting crops from last year. You would like to apply the herbicide at the same time as you seed the new grain.

DATA SHEET THREE



WEED PROBLEM THREE

You are responsible for maintaining the lawns around a large factory and office complex. One area is infested with broad leaved weeds (dandelions, plantain, Canada thistle). You want to remove the weeds without damaging the lawn grass.

WEED PROBLEM FOUR

A field of growing potatoes has become overgrown with wild grasses. The grass plants must be destroyed without damaging the potato plants or making the potatoes inedible.

DATA SHEET FOUR



WEED PROBLEM FIVE

You wish to remove broad leaved, annual weeds (chickweed, lamb's quarters, stinkweed) from a growing field of carrots. The carrot plants must not be killed, nor the carrots contaminated with herbicide residues.

WEED PROBLEM SIX

In a field of barley, you discover a high percentage (20% of plants) of wild oats and crested wheat grass. You want to remove the wild grasses without damaging the barley.



TASK SHEET ONE

We worked on problem number _____

Of the herbicide choices available
we feel that _____
will be successful on our problem.

Group Members

Our major reasons for choosing this controls are:

1.

2.

3.

4.

ACTIVITY 8



It's a Gas

Objective:

Students calculate the amounts of methane and electricity that can be generated by anaerobic fermentation of animal wastes.

Curriculum Fit:

Science 20, Unit III
Technologies of Energy Systems

Science Concepts:

The production of biofuels depends upon fermentation. Scientists are devising technology that can be utilized to extract energy from biomass to produce biofuels.

Skills:

Demonstrate skill in designing and/or building a biogas generator.

Attitudes:

Appreciate the creativity exhibited in devising alternative methods of utilizing biomass energy. Value the potential of using biomass as an alternative energy source.

Agriculture Concepts:

Capital and Technology Intensity

Cognitive Level:

Application

Materials Required:

Enclosed data and task sheets only

Time Required:

One period



BACKGROUND - For the Teacher

The idea of generating methane gas through the anaerobic decay of organic waste has been raised frequently since the 1974 oil supply crisis. The technical requirements of the process are well understood, and considerable research has been done at both the engineering and do-it-yourself levels.

In this activity your students are introduced to the process with a series of data sheets. They are then asked to calculate energy outputs both as volumes of biogas and kilowatt hours of electricity from some full scale livestock operations. These businesses are slightly larger than average for Alberta but not unheard of here. The lesson concludes with discussion questions in the practicability and implications of this process.

NOTE

The actual product of this fermentation is called biogas. It is about 60% methane and 40% carbon dioxide, with traces of water, ammonia and hydrogen sulfide.

SECOND NOTE

When your students begin Task Sheet One, tell them that they may assume that their collection efficiency is 90%.

PROCEDURE

Part 1

Preparation:

1. Prepare handout sheets or overhead transparencies of data sheets one to five.
2. Prepare one copy of data sheet six for every four students and one copy of the task sheet for every student.

Part 2

Introduction:

3. Using data sheets one to five explain the biological process of anaerobic digestion (sheet one) and the technology and limitations of getting it done (sheets two, three, four).
4. Distribute data sheet six and explain that its figures allow anyone to calculate biogas production for four types of animal. Each student will only do calculations for one column.

Part 3

Activity:

5. Students select one type of animal by lottery, numbering or other randomizing method.
6. Using the information in data sheet six, students complete the calculations to determine how much biogas they would produce and how big a digester they would require for one of these operations:
 - a. a 100 cow dairy
 - b. a 5,000 steer feedlot
 - c. a 50,000 hen egg farm
 - d. a 300 hog finishing barn



Part 4

Conclusion:

7. Have students compare energy yield and digester size requirements. Display results for class.
8. Lead a discussion, based on the questions below, of the practicality of this process.

DISCUSSION QUESTIONS

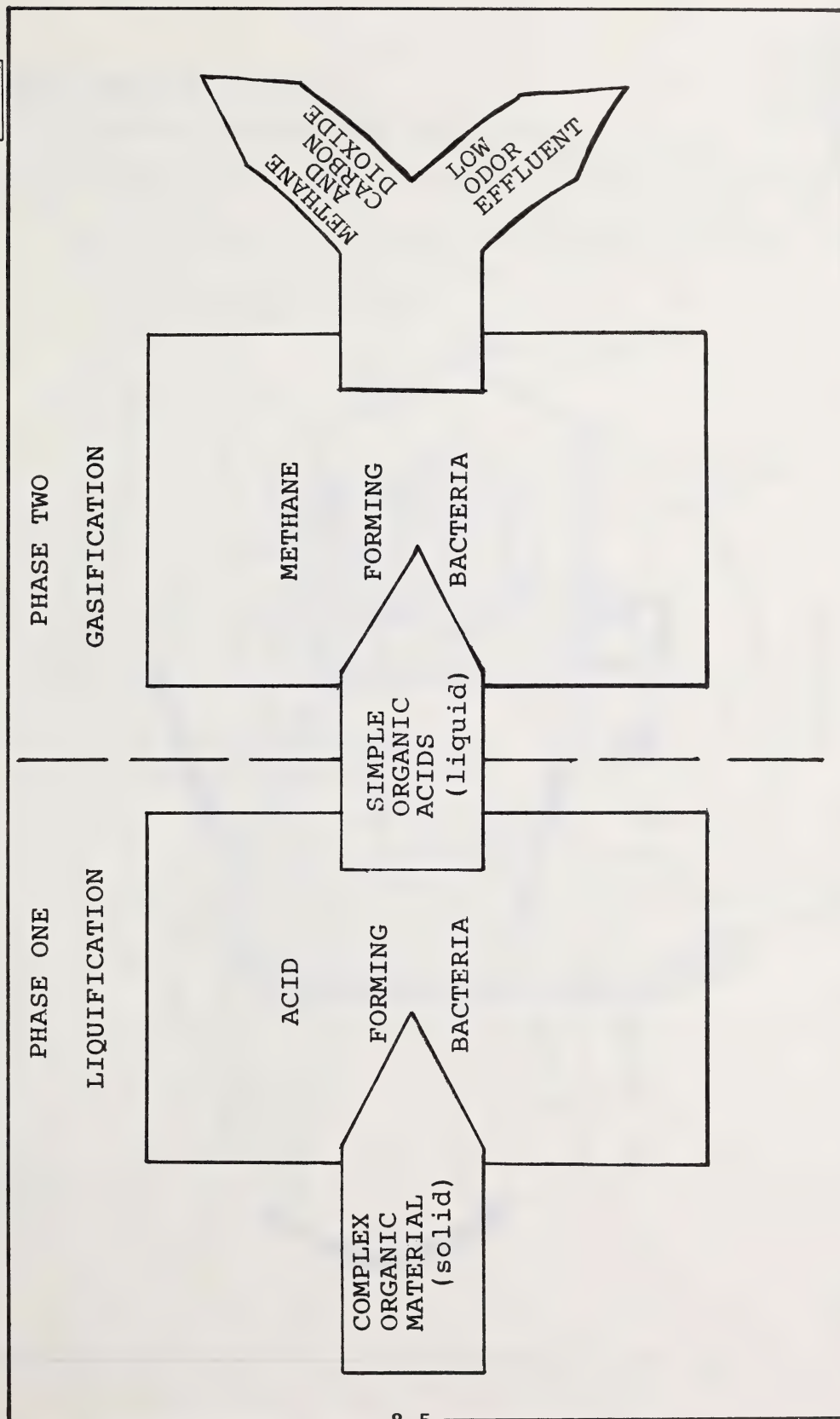
1. What information do you need to determine whether the energy produced in your system is worth the cost of producing it?
2. What are some non-monetary benefits of this technology and who receives them?
3. If the non-monetary benefits are high to society in general and the monetary costs are high to the farmer, how can the general society get the farmer to provide this benefit?
4. What factors prevent methane from being used as a vehicle fuel?

RELATED ACTIVITIES

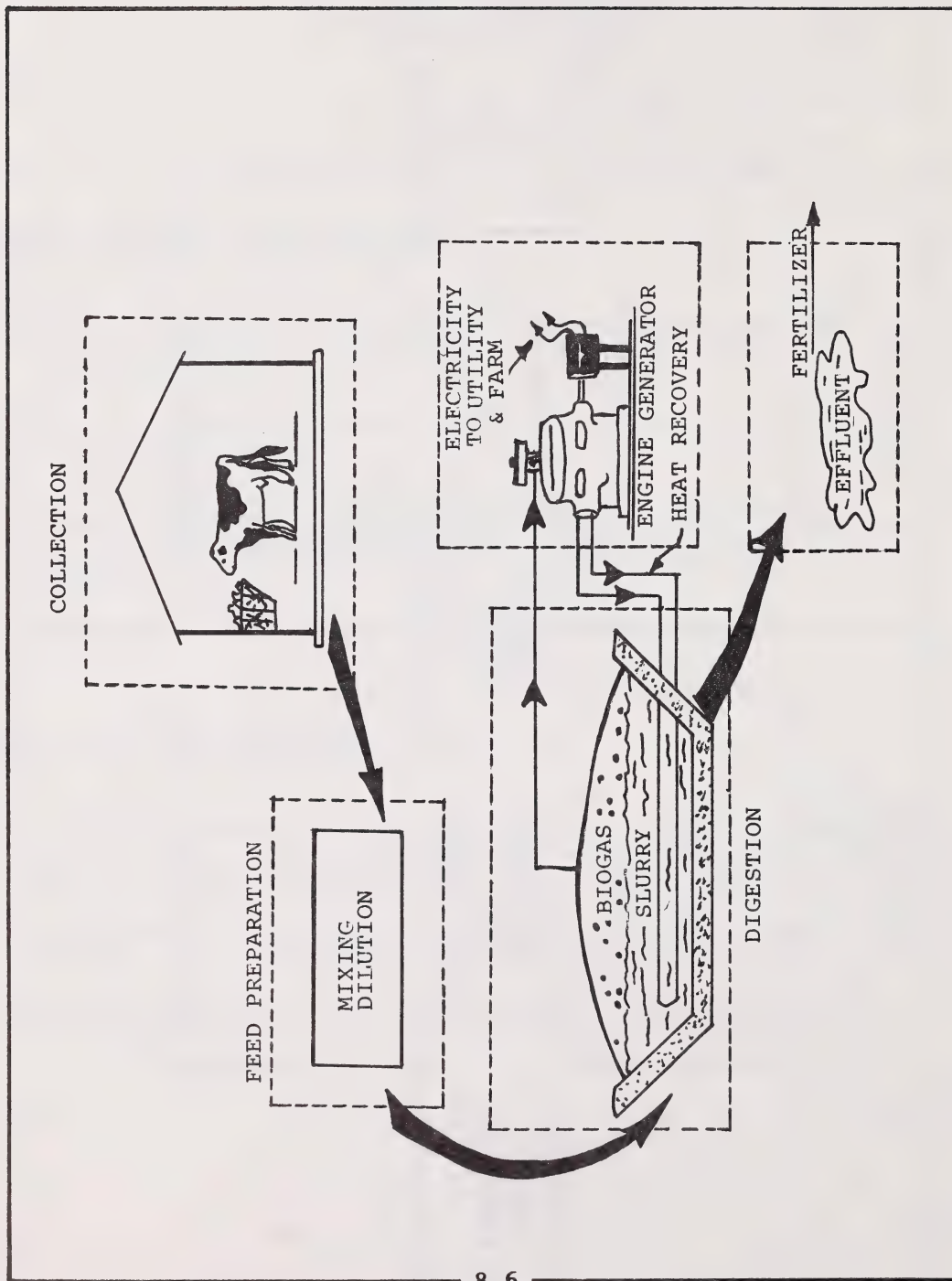
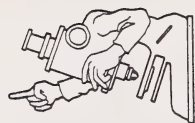
1. Invite a speaker from your nearest electrical or natural gas utility to explain the technology of generating their type of energy and delivering it to your home.
2. Research and report on the technology by which fuel alcohol can be made from plant materials.
3. Investigate the technology of using process heat to warm greenhouses.



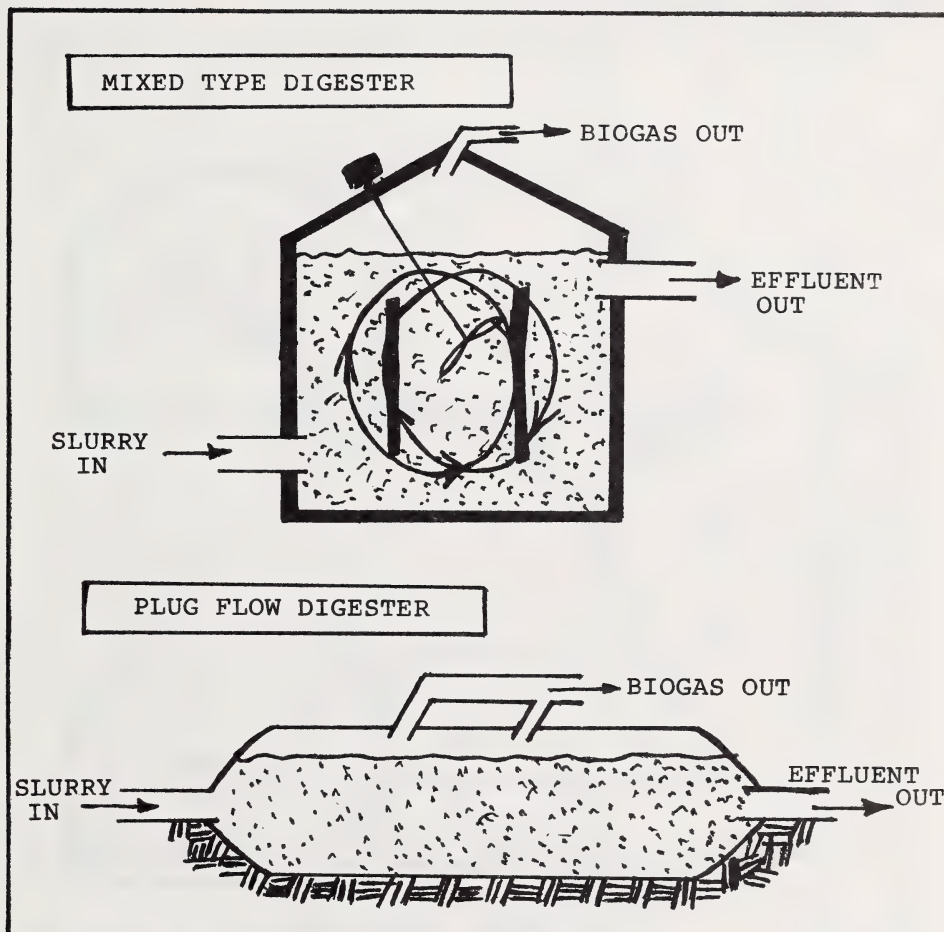
DATA SHEET ONE: THE BIOLOGICAL PROCESS



DATA SHEET TWO: BIOGAS SYSTEM SCHEMATIC

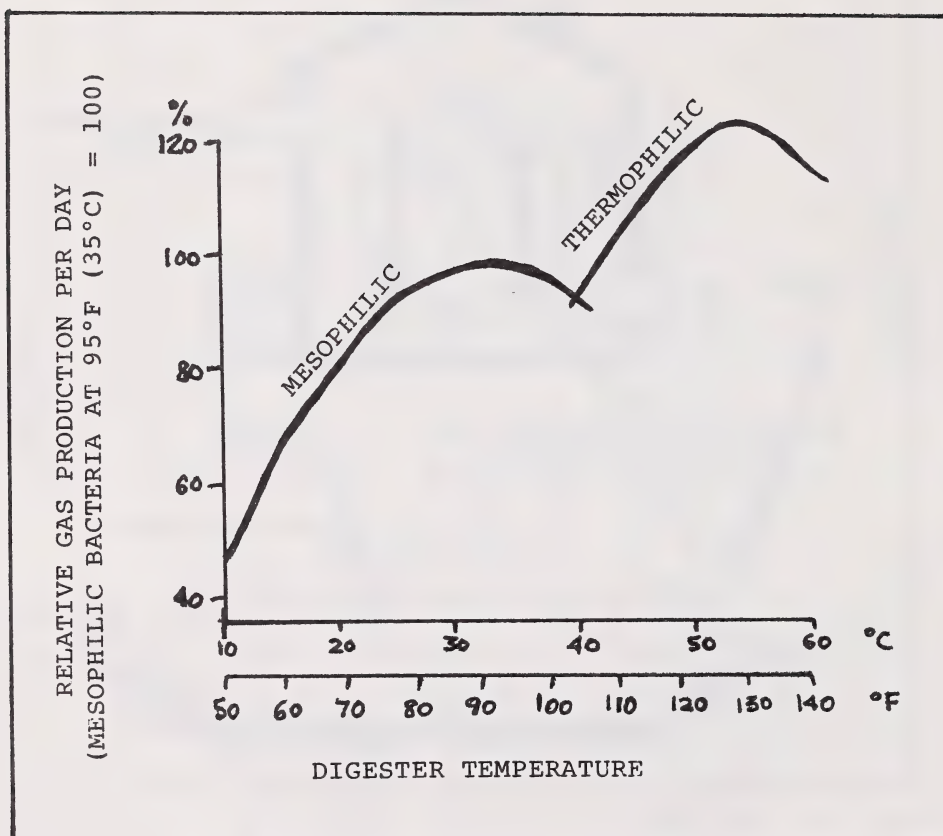
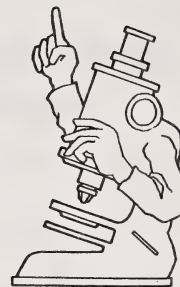


DATA SHEET THREE: TYPICAL DIGESTER DESIGNS

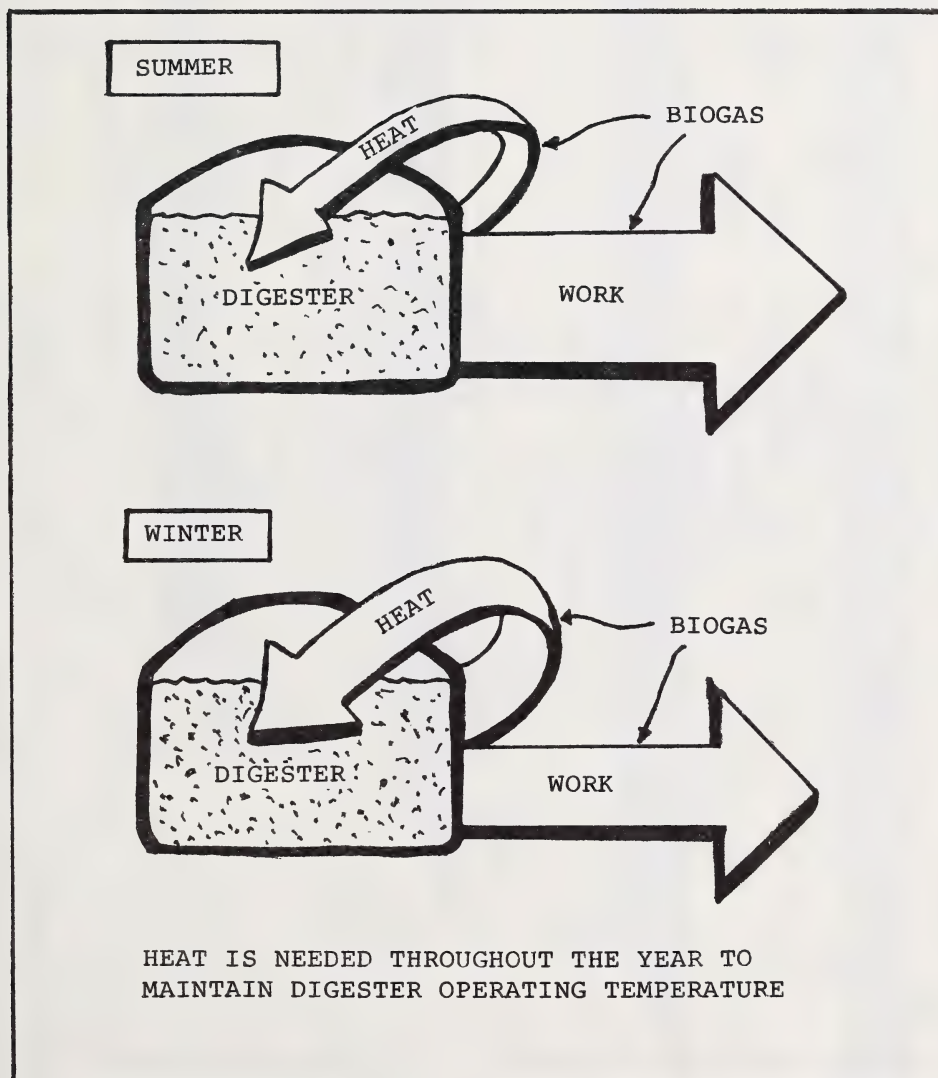


DATA SHEET FOUR

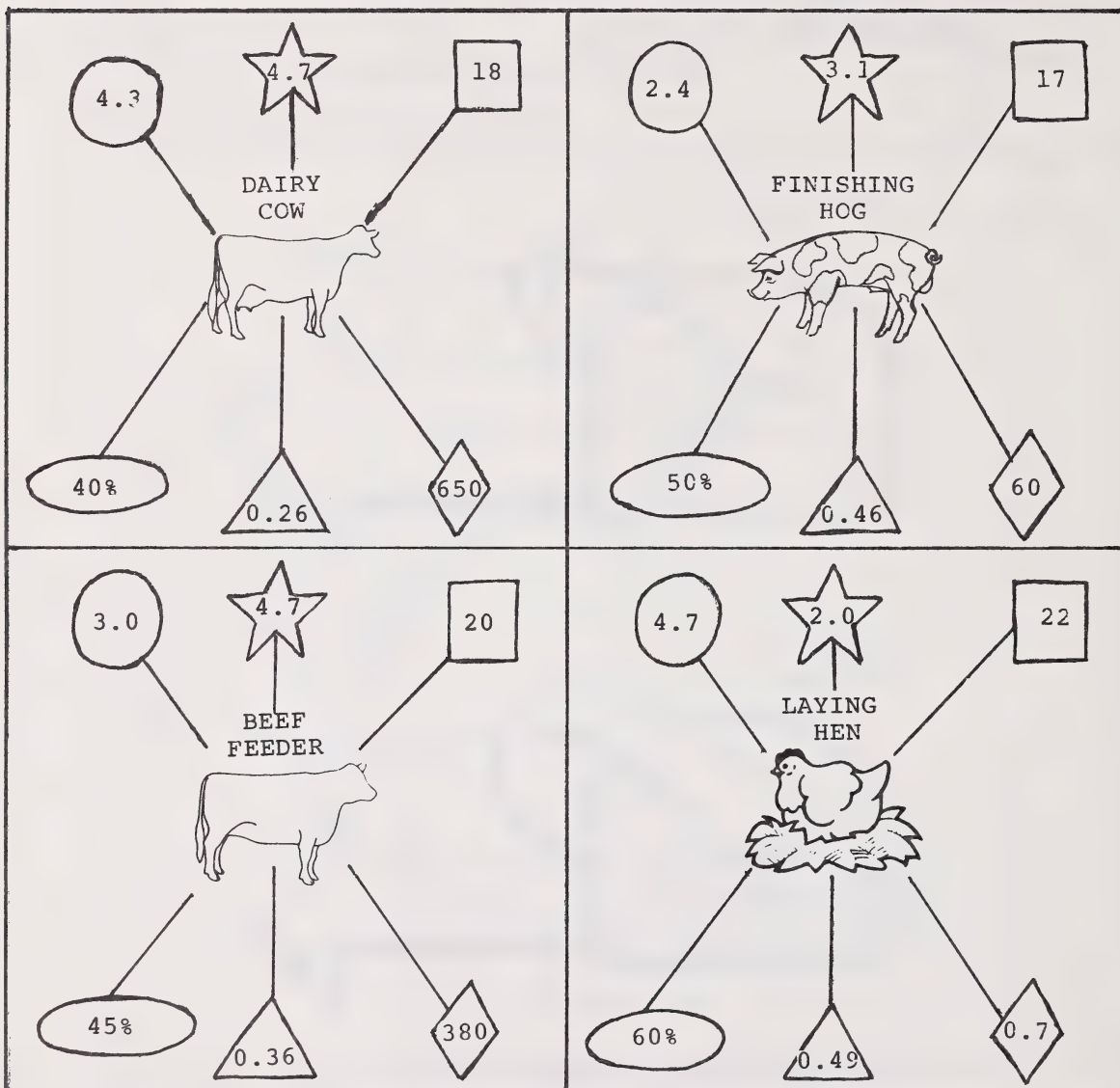
EFFECT OF TEMPERATURE ON GAS PRODUCTION RATE



DATA SHEET FIVE DIGESTER HEATING



DATA SHEET SIX: ANAEROBIC DIGESTER DESIGN FIGURES



LEGEND:

- - Daily Unit Waste Production - (kg dry weight/day/500 kg liveweight)
- ☆ - Loading Rate - (kg dry waste/m³ of digester/day)
- - Retention Time - (days)
- - Conversion Efficiency - (per cent of solids converted to biogas)
- △ - Production Rate - (m³ biogas/kg dry waste)
- ◇ - Average weight - (kg)



TASK SHEET ONE: CALCULATING ENERGY PRODUCTION

STEP 5

$$\text{Energy in Biogas} \times 0.22 \times \text{Conversion Constant} = \text{Electrical Energy}$$

$$\text{kJ/day} \times 6.11 \times 10^{-5} \text{ Kwh/kJ} = \text{Kwh/day}$$

STEP 4

$$\text{Daily Biogas Production} \times \text{Heat Value of Biogas} = \text{Total Energy in Biogas}$$

$$\text{m}^3/\text{day} \times 2.152 \times 10^4 \text{ kJ/m}^3 = \text{kJ/day}$$

Note: This heat can be converted to electricity at 22% efficiency.

STEP 3

$$\text{Total Daily Waste} \times \text{Production Rate} = \text{Daily Biogas Production}$$

$$\text{kg/day} \times \text{m}^3/\text{kg} = \text{m}^3/\text{day}$$

STEP 2

$$\frac{\text{Total Mass}}{500} \times \text{Daily Unit Waste Production} \times \text{Collection Efficiency} = \text{Total Daily Waste}$$

$$\text{kg} \times \text{kg/day/500 kg} \times \text{kg/day/500 kg} = \text{kg/day}$$

STEP 1

$$\text{Number of Animals} \times \text{Average Mass} = \text{Total Mass}$$

$$\text{kg} \times \text{kg} = \text{kg}$$

TASK SHEET TWO: CALCULATING DIGESTER SIZE



STEP 3				
Total Litres	÷	Retention Time	=	Daily Liquid Volume
_____ l	÷	_____ days	=	_____ litres/day
STEP 2				
Total Digester Volume	X	Conversion Factor	=	Total Litres
_____ m ³	X	1000 l/m ³	=	_____ l
STEP 1				
Total Daily Waste	÷	Loading Rate	=	Total Digester Volume
_____ kg/day	÷	_____ kg/m ³ /day	=	_____ m ³

ACTIVITY 9

Fueling the World of Wheels



Objective:

Students will investigate the technology of producing fuel ethanol and evaluate it as an alternate vehicle fuel.

Curriculum Fit:

Science 20, Unit III
Biomass Energy

Science Concepts:

The production of biofuels depends upon fermentation. Scientists are devising technology that can be utilized to extract energy from biomass to produce biofuels.

Skills:

Apply decision making skills, including researching, identifying and evaluating alternatives and formulating an informed decision.

Attitudes:

Appreciate the creativity exhibited in devising alternative methods of utilizing biomass energy. Value the potential of using biomass as an alternative energy source.

Agriculture Concepts:

Diversity
Economic Importance

Cognitive Level:

Evaluation

Materials Required:

Included

Time Required:

One hour



BACKGROUND - For the Teacher

Ethanol is the second biomass-based substance widely suggested as an alternative fuel. Being a liquid at normal temperatures, ethanol can be used as a vehicle fuel far more readily than can biogas.

Some countries, notably Brazil, have invested heavily in industrial-scale fuel ethanol plants, hoping to reduce their dependence on oil imports. Interest in North America has been lower; one plant exists in Manitoba, a few in the United States. Further development appears to depend on economic factors not technical ones.

From an agricultural perspective, fuel ethanol has two attractions. First, a plant would require large volumes of farm produce as a feedstock. This would increase the volume and variety of markets for farmers. Second, some producers feel that producing their own fuel from unmarketable grain would reduce the cost of their operations.

In this lesson your students will investigate the apparent advantages. Phase one of these lessons presents the process by which motor fuel grade alcohol (MFGA) is produced. In phase two, students consider the dollars and cents of building and operating farm scale ethanol plants. Finally, students consider how the MFGA technology fits into the overall fuel needs of Canadian society.



PROCEDURE

Part 1

Preparation:

1. For phase one of the activity, prepare overhead transparencies or handout copies of Data Sheets One, Two and Three.
2. For phase two, make handout copies of Data Sheet Four.

Part 2

Introduction:

3. Explain that ethanol can be used as a motor fuel if it can be purified sufficiently.

Part 3

Activity:

Phase 1:

4. Use data sheets one to three to explain the process of developing motor fuel grade alcohol.

NOTE

The process from grain to first distillation is the same as that for producing beverage alcohol.

Phase 2:

5. Explain the two advantages of fuel alcohol from an agricultural perspective.
6. Distribute Data Sheet Four, and ask students to evaluate advantage two (reduced fuel payments) in terms of the costs shown.

Part 4

Conclusion:

7. Lead the class in a discussion of the questions below.

DISCUSSION QUESTIONS

1. As the owner-operator of a MFGA plant in central Alberta you find that the local barley you have used for the last three years will cost three times as much as it did last year. What are you going to do?
2. It is possible to synthesize ethanol from ethylene (made from natural gas) at about half the cost of the fermentation-distillation process described. What advantage does the biomass based product offer to compensate for the cost?
3. How is farming to produce food different from farming to produce fuel?
4. Is the answer to question three different for a Canadian landowner than for a Brazilian landowner? (Each person should give reasons for their answer.)

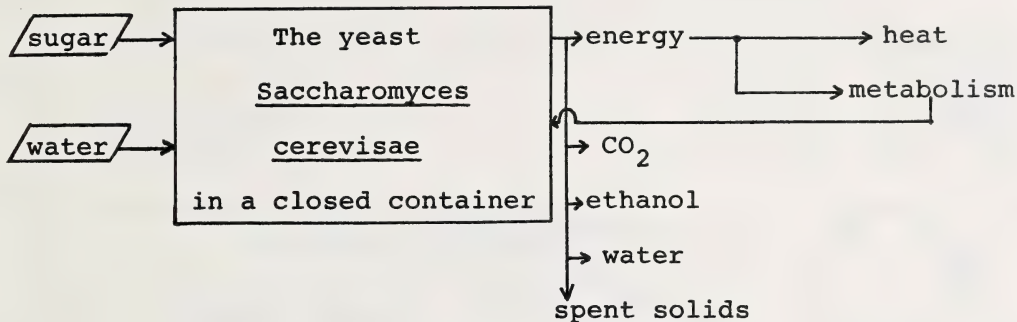
RELATED ACTIVITIES

1. Have students role play a grain price negotiation between a farmer, a fuel alcohol manufacturer and a grain exporting company. Allow students to evaluate the negotiations as if they were either a petroleum industry spokesman or the Prime Minister of Canada.

DATA SHEET ONE ETHANOL PRODUCTION



It is easy to produce ethanol.



Ethanol is toxic to the yeasts that make it.
As ethanol concentration approaches 15% it kills enough yeast cells to stop fermentation.

Heat dissipates by conduction, convection or radiation.

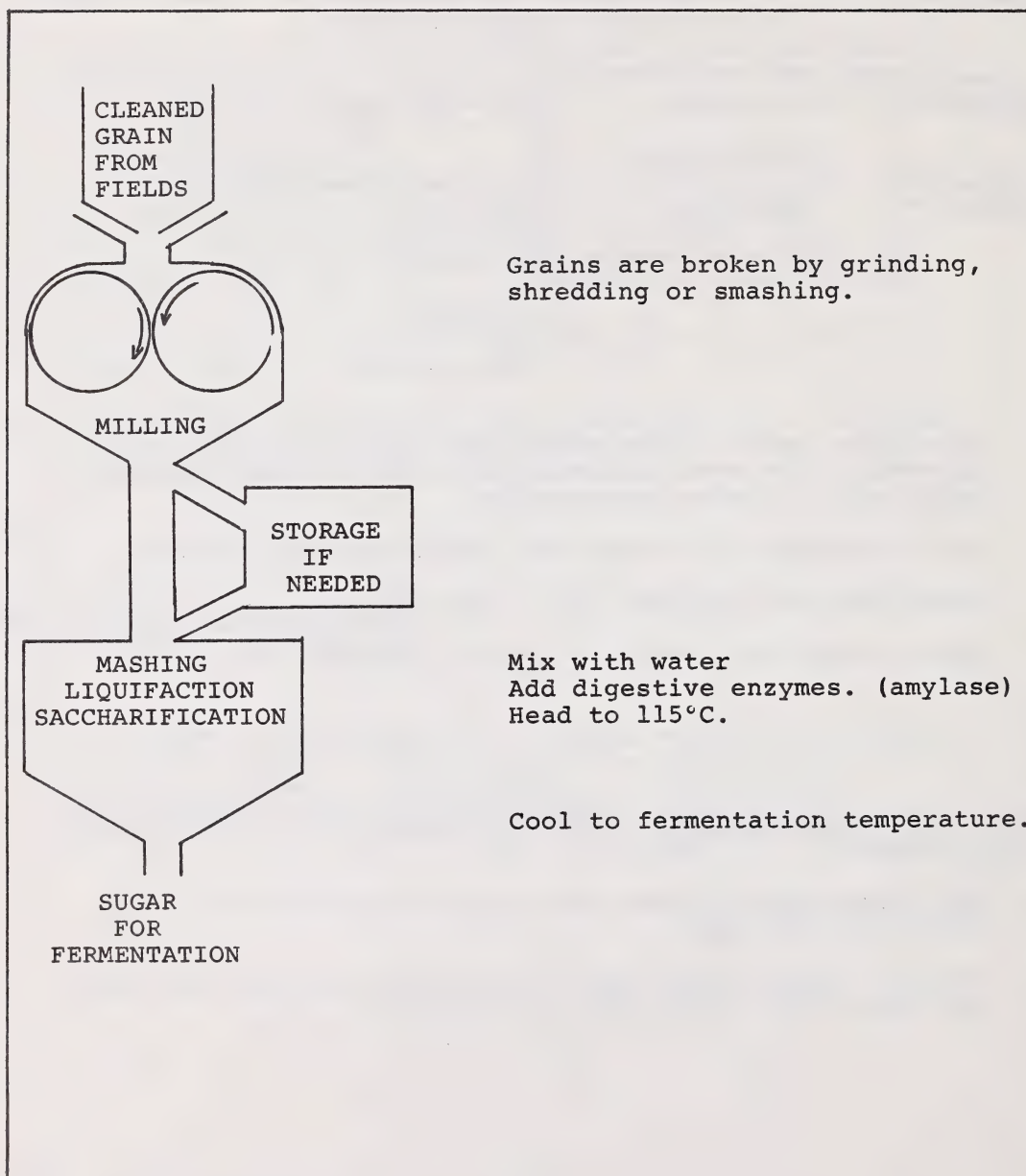
Carbon dioxide is given off to the air.

Spent solids will settle or can be filtered out.

This leaves two problems in terms of making fuel ethanol from farm products:

1. Most farm products have their sugar molecules tied up as starch or cellulose.
2. Ethanol concentration must be above 95% to power an engine and above 99% to mix well with gasoline.

DATA SHEET TWO SOLVING PROBLEM ONE



DATA SHEET THREE

SOLVING PROBLEM TWO

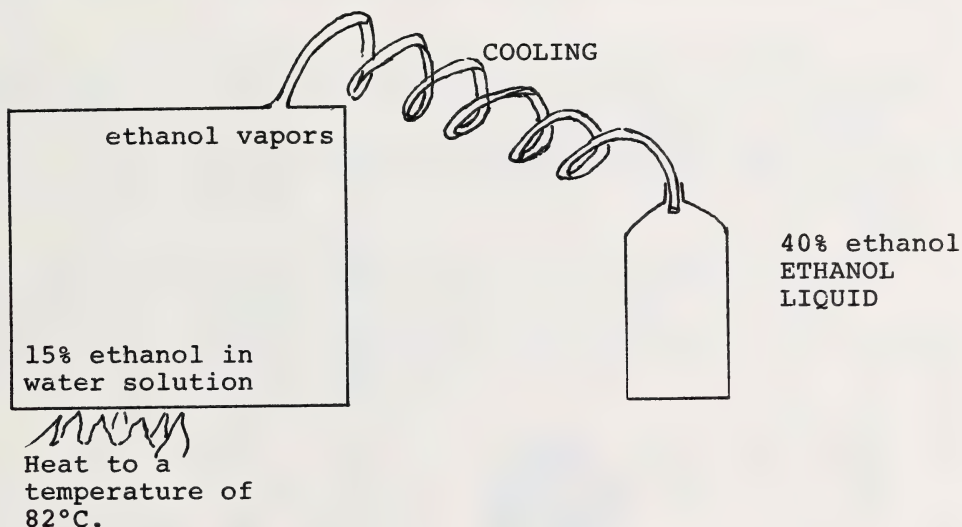


DISTILLATION is the basic process for separating two liquids in solution.

It depends on each liquid having a unique boiling point.

EVAPORATIVE SEPARATION

BP Water = 100°C
BP Ethanol = 82°C



If you can:

1. Control temperature and pressure in the evaporator,
2. Use an efficient condensor,
3. Repeat the process with your distillate,

Then you can distill to about 95% ethanol, 5% water.

This is Hydrous Fuel Alcohol. It can be used as a straight fuel for heater, grain dryers and vehicles with modified engines.

If you can:

1. Mix Hydrous Fuel Alcohol with a liquid that attracts water but not ethanol,
2. Redistill this new mix under high pressure,

Then you can produce 99.5%+ ethanol.

This is Anhydrous Motor Fuel Grade Alcohol. It can be added to gasoline and burned in any unmodified gasoline engine.



DATA SHEET FOUR

COST OF ETHANOL FROM FARM-SCALE PLANTS*

PLANT NUMBER	FEEDSTOCK	CAPACITY (L/Hr)	PRODUCTION COST (\$/L) 95% HFA	PRODUCTION COST (\$/L) 99.5% MFGA
1	corn	570	0.42	0.45
2	wheat	570	0.57	0.60
3	sugar beets	190	0.68	0.74
4	barley	190	0.46	0.49
5	rice	60	1.01	1.05
6	corn	60	0.73	0.78

* adapted from Rafael Katzen Associates International, Inc.
report to National Alcohol Fuels Commission
Washington, D.C. 1980.

NOTE: In 1989, the production cost of gasoline varies
between \$0.20 and \$0.23 per litre.

SECTION C: SCIENCE 30

Every unit in the program of studies for Science 30 includes topics that are well illustrated in agriculture.

Energy matters, the subject of Unit I, affect agriculture both directly and indirectly at all stages of food production and processing. Activities Nine and Ten in Section B deal with renewable energy sources that can be evaluated for this unit.

Two lessons deal with Unit II: Canadian Chemical Industries. In Activity Ten students discover how chemical fertilizers are developed in present day plants. Activity Eleven shows students an organic source of biodegradable plastics and asks them to describe how such a plastics industry would affect society.

Activity Twelve deals with biotechnology and genetic engineering, the subjects of Unit III. Genetics began in agriculture, and agriculture has always been a primary beneficiary of genetic advances. In this lesson your students will evaluate genetic engineering and make decisions based on its potential and dangers.



ACTIVITY 10



Food for Plants

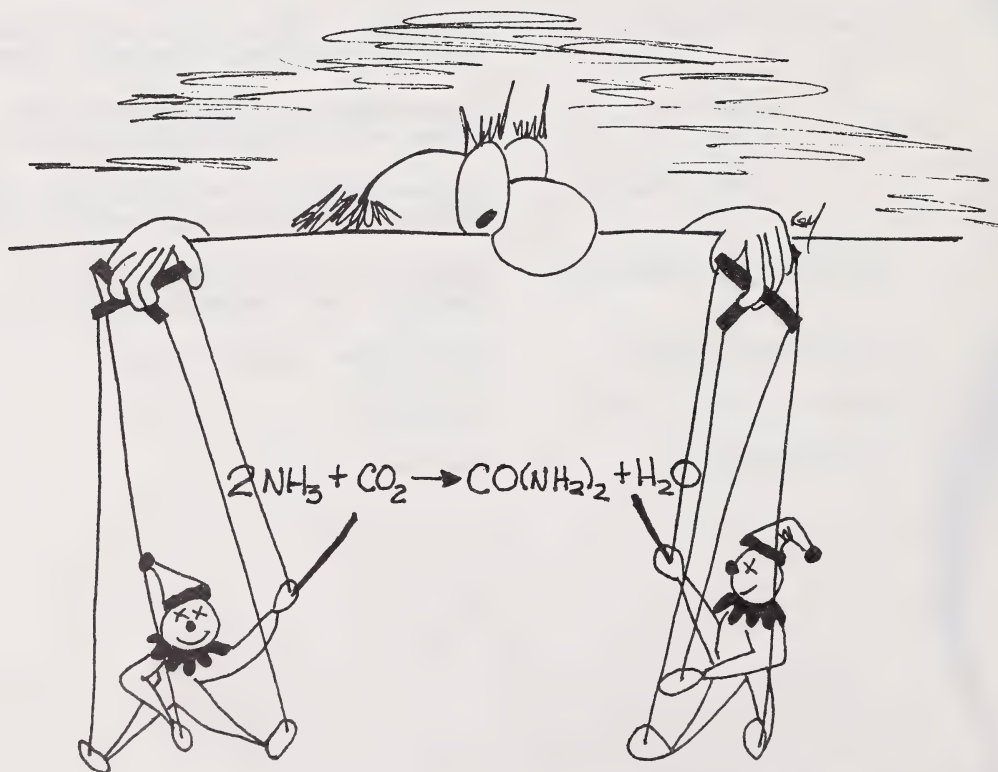
Objective:	Students will identify the need for plant nutrients and learn how inorganic fertilizers are made.
Curriculum Fit:	Science 30, Unit II Canadian Chemical Industries
Science Concepts:	Nitrogen, phosphorus and sulfur are used to produce inorganic fertilizers.
Skills:	Recognize the components and interactions within a system.
Attitudes:	Appreciate the relationship among science, technology and society.
Agriculture Concepts:	Economic Importance Capital and Technology Intensity
Cognitive Level:	Knowledge, Application
Materials Required:	Included
Time Required:	One hour



BACKGROUND - For the Teacher

Fertilizer production is a major chemical industry in Alberta. There are fertilizer manufacturing plants in the province, employing people and producing tonnes of fertilizer per year.

This lesson looks at the process of making fertilizers. Data sheets one to three deal with plant nutrient requirements and establish the basis for fertilizer use. Data sheets four to six look at how fertilizer is actually made. Sheets four and five focus on nitrogen; sheet six shows phosphorus and potassium. In fact, in Alberta, nitrogen and phosphorus are normally processed together to yield various N.P. analysis fertilizer.



PROCEDURE

Part 1

Preparation:

1. Prepare overhead transparencies or hand out copies of the data sheets.

Part 2

Introduction:

2. Using Data Sheet One lead the class in considering Discussion Questions one to four.
3. Use Data Sheet Two to consider Discussion Questions five and six.
4. Have students compare Data Sheet Three with Data Sheet One and predict what effects the fertilizers shown would have on plant growth.

Part 3

Activity:

5. Use data sheets four, five and six to describe how inorganic fertilizers are made.

Part 4

Conclusion:

6. Lead the class in a discussion on the question "Why is Alberta well suited to have a major fertilizer production industry?".

DISCUSSION QUESTIONS

1. Are the essential plant nutrients clustered in particular columns of the periodic table?
2. Can we expect particular chemical activity from the nutrients based on their positions in the periodic table?
3. Are there particular forms that the nutrients must be in to be usable by plants?
4. Do the nutrients go through ecological cycles?
5. What two factors in Data Sheet Two ensure that plant nutrients will decline soil cultivated for crops?
6. Knowing that on any field you would always be withdrawing nutrients at D, how could you maintain nutrient levels there using crop residues and manures?
7. Speculate on why potassium (K) is absent from most fertilizers sold in Alberta.

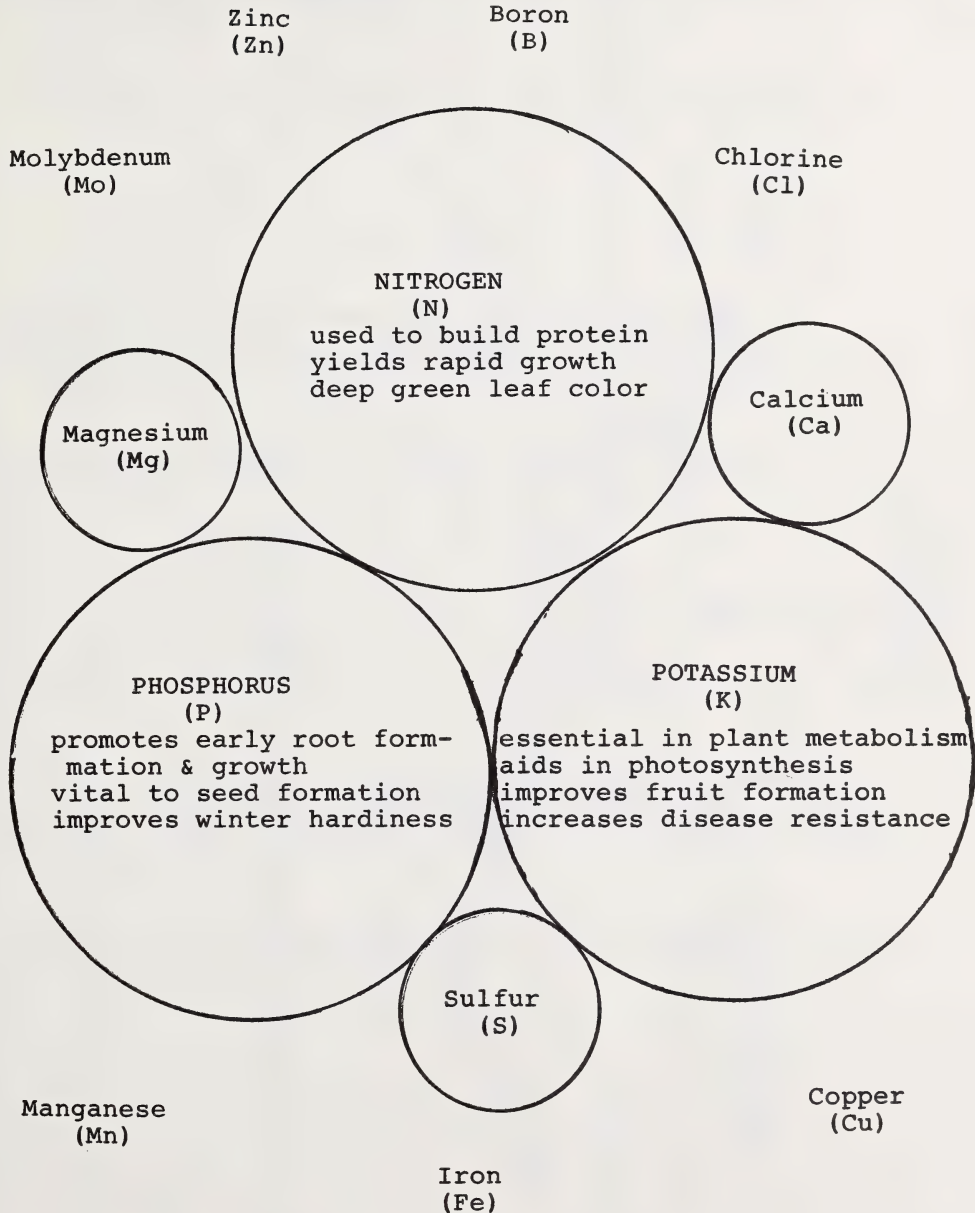
RELATED ACTIVITIES

1. Fertilize growing plants according to package directions with fertilizers of different analyses and record the results. (Use one pot or flat per fertilizer.)
2. Fertilize growing plants with equal amounts of fertilizers having different analyses and record results.
3. Compare chemical fertilizer with manure and with nitrogen-fixing bacteria as sources of soil nitrogen for plants.
4. Invite a guest speaker to describe the fertilizer industry in Alberta and what careers it involves.
5. Show the video "Plants for Food, Food for Plants".



DATA SHEET ONE PLANT NUTRIENT NEEDS

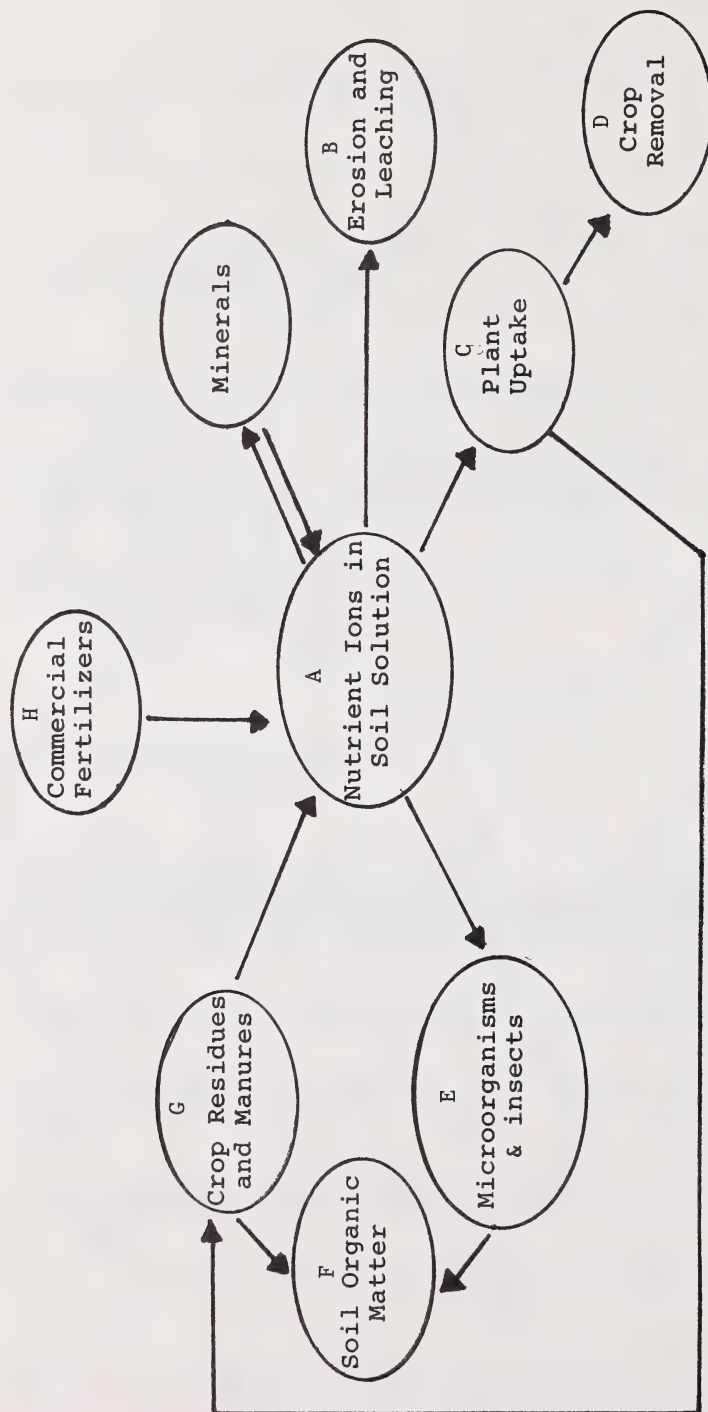
(Ranked by amounts required)





DATA SHEET TWO

NUTRIENT CHANGES IN SOILS





DATA SHEET THREE INORGANIC FERTILIZERS

Inorganic or chemical fertilizers may be available as

- compressed gas
- dissolved ions
- granules

These fertilizers contain one or more of the macronutrients (nitrogen, phosphorus and potassium). Some also contain the secondary nutrient sulfur.

Fertilizers are identified by analysis numbers.

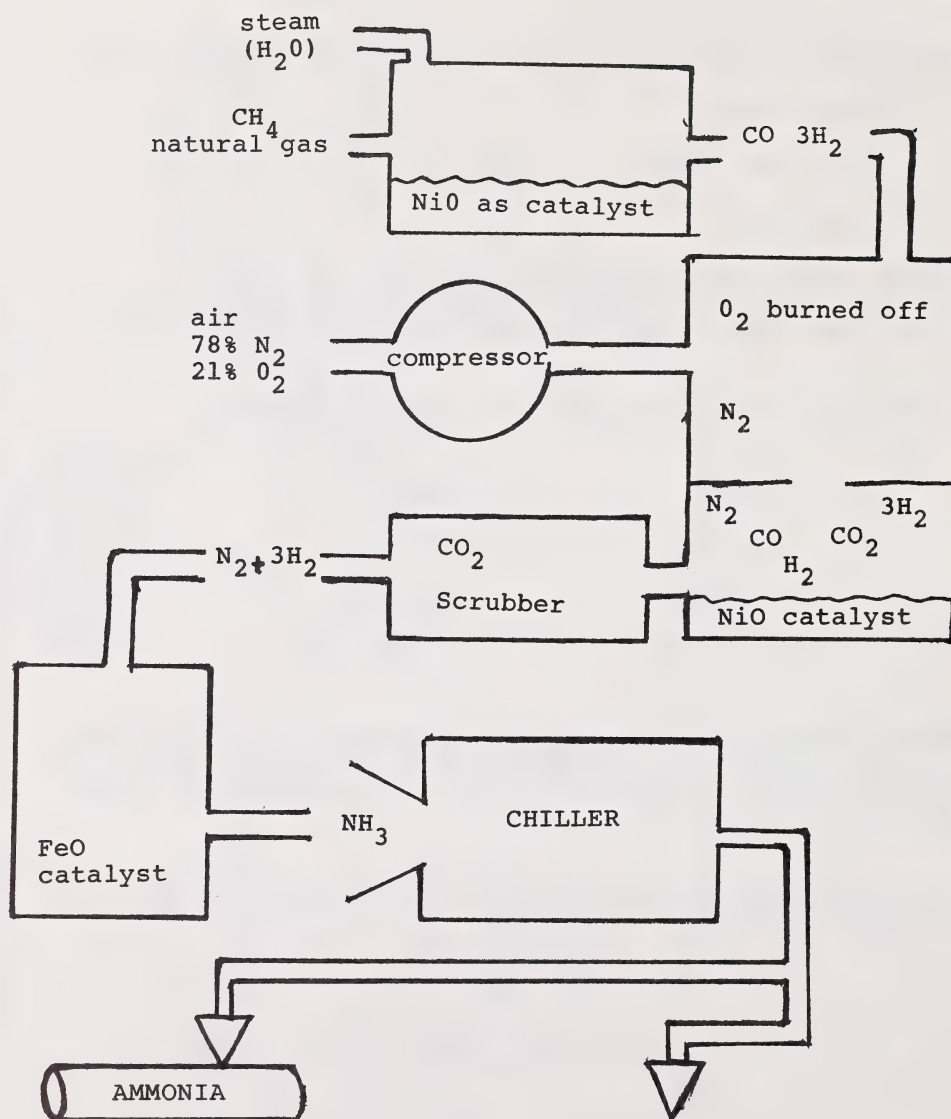
82-0-0	(NPK)
16-20-0	(NPK)
20-20-20	(NPK)
20-0-0-24	(NPKS)

These numbers are the percent by weight in order of the nutrients Nitrogen, Phosphorus and Potassium. If a fourth number is present it gives the percent by weight of Sulfur.

The difference between 100% and the total given analysis is made up of inert materials.



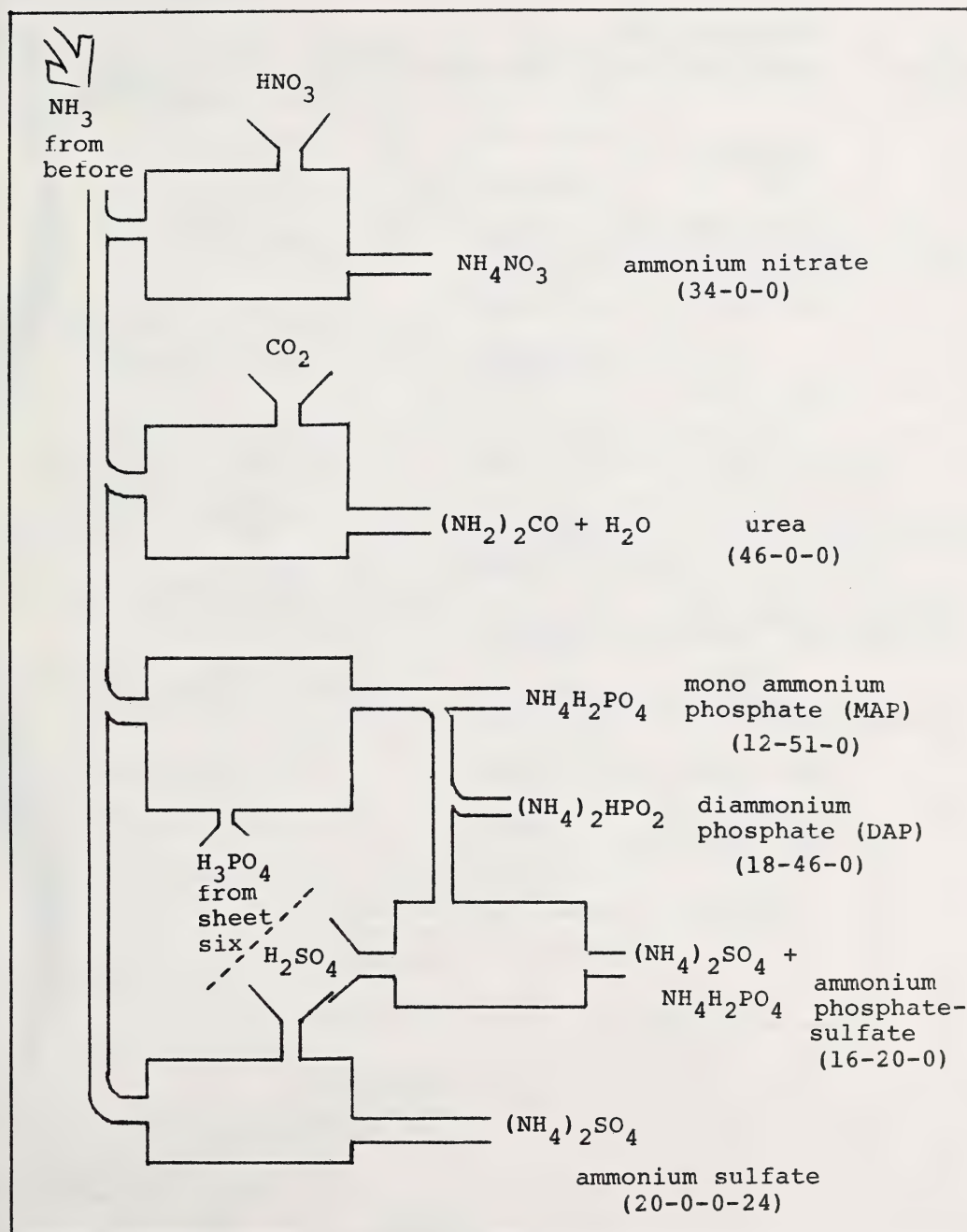
DATA SHEET FOUR — MAKING FERTILIZER



Anyhydrous Ammonia
sold as a compressed gas
for fertilizer (82-0-0)

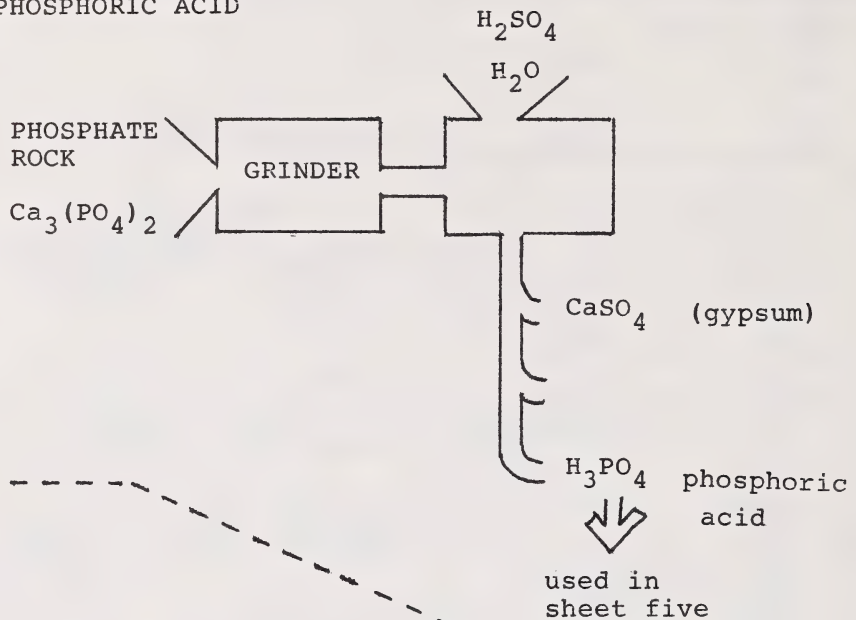
Conversion to other
fertilizers as on
next sheet

DATA SHEET FIVE AFTER AMMONIA

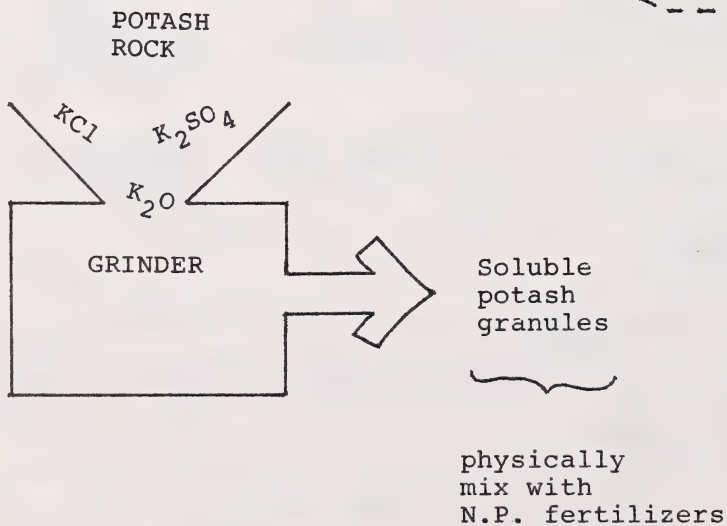


DATA SHEET SIX

A. PHOSPHORIC ACID



B. POTASSIUM



ACTIVITY 11



Down in the Nutrient Valley

Objective:

Based on the ideas of some agriculture researchers and processors, students will consider how to develop a starch-based chemical industry.

Curriculum Fit:

Science 30, Unit II
Canadian Chemical Industries

Science Concepts:

Organic chemistry is the study of the molecular compounds of carbon.

Skills:

Analyse critically the possible impact of scientific research and technological development on society.

Attitudes:

Appreciate the relationship among science, technology and society.

Agriculture Concepts:

Diversity
Capital and Technology Intensity

Cognitive Level:

Application, Synthesis

Materials Required:

Samples of polyethylene products

Time Required:

One hour



BACKGROUND - For the Teacher

For several years, organic chemists and environmentalists have been attracted by the idea of a plastic that would be biodegradable and that could be made from renewable resources. One chemical that may serve as such a plastic is called polyhydroxybutyrate.

Polyhydroxybutyrate is a long chain polymer formed from hydroxybutyric acid by esterification. The hydroxybutyric acid building block itself results from the breakdown of starch. As in the formation of present day plastics, the polymerization process can be controlled to yield straight line, branched or cross-linked chains. Each of these will yield a plastic with different characteristics. Finally, the nature of the base molecule means that on exposure to environmental influences polyhydroxybutyrate will decompose from microbial action.

In this lesson your students begin with two short readings describing proposals for agricultural diversification based on processing of grains beyond simple foodstuffs. Based on one suggestion they then compare the chemistry of polymer formation using ethylene (one current method) with the same process using hydroxybutyric acid. Students conclude by considering how a plastics industry based on a renewable resource and a biodegradable product would affect society.

SPECIAL NOTE

The readings that make up data sheets one and two are taken from RESEARCH REPORT, a publication of the Research Division of Alberta Agriculture. RESEARCH REPORT is published 10 times a year and can be obtained by writing to:

Alberta Agriculture
Research Division, Research Report
#202, J.G. O'Donoghue Building
7000 - 113 Street
Edmonton, Alberta
T6H 5T6

PROCEDURE

Part 1

Preparation:

1. Copy the readings and task sheets so that each student will have one.
2. Convert data sheets one and two into overhead transparencies or handout sheets (one per student).
3. Obtain samples of various polyethylene objects to illustrate the varied characteristics the molecule can have (e.g. plastic sheeting, combs, food containers, ski bases are all available in polyethylene).

Part 2

Introduction:

4. Explain that chemical research and engineering are the basis of much of our present society, and that many of our present problems may respond to scientific solutions.
5. Distribute data sheets one and two and ask students to read them.

Part 3

Activity:

6. Ask the class to discuss how the speakers quoted in each article feel science can contribute to solving some of Alberta's economic problems.
7. Ask the students to focus on paragraph five of the first reading, and tell them that they will be considering existing and biodegradable plastics.
8. Distribute Data Sheet Three, or display it on overhead. Lead students through the process and have them orally answer the questions on Task Sheet One. If you have assembled polyethylene samples, introduce them into this phase of the discussion.



9. Repeat Step 8 with Data Sheet Four. Have students complete Task Sheet Two in writing.

Part 4

- Conclusion:
10. Lead a class discussion of the question "How would a polyhydroxybutyrate society differ from today's polyethylene one?"

DISCUSSION QUESTIONS

1. What is the advantage of a biodegradable plastic in terms of garbage disposal?
2. What are some advantages of a renewable resource-based plastic?
3. List as many plastic products as you can (as a class) and decide which ones would be better if made from biodegradable plastics. Which ones need the indestructibility they now have?
4. How would using 120,000 tonnes per year of crop derived starch for plastic production affect:
 - a) the price of grain and food?
 - b) the natural gas industry?
 - c) expansion of ethylene plants in central Alberta?

RELATED ACTIVITIES

1. Investigate one of the products or processes mentioned by Dr. Evans in Data Sheet 2.
2. Find out the structure of styrene and how it is converted to polystyrene.
3. Invite a chemical engineer to explain how industrial chemistry processes are controlled to ensure that plastics with many possible forms can be made into products with constant and predictable characteristics.



Alberta
AGRICULTURE

Volume 2 Number 4 March, 1988

Research Report



Nutrient Valley, Alberta

Putting agri-industry on the map

One of the more intriguing proposals for agricultural diversification put forth at Alberta Agriculture's, Alternative Crops Conference in Lethbridge last November is the brainchild of Mr. Percy Gitelman, president of UFL Foods in Toronto. He suggests Alberta should establish a "Nutrient Valley," similar in concept to California's famous "Silicon Valley," a community of high-tech firms where intellectual resources, new technology and financial capital have been concentrated with spectacular results.

Mr. Gitelman envisions a community of industrial plants which would extract nutrients and other products from agricultural crops and create new products. He notes that plants, just like petroleum, consist of building blocks, for instance, starches and cellulose. These can be extracted, altered and reassembled in a wide variety of profitable ways.

The advantages of concentrating these

agricultural-industrial operations in one area would be the same as in California, with the added advantage that in this kind of production, the by-products of one plant can often be put to good use in other processing operations.

According to Mr. Gitelman, only 2.1% of Canadian wheat and 0.4% of Canadian barley are used to create value-added products other than animal feeds. Non-traditional uses for our food products would expand Canadian markets and would provide a boost to the secondary processing industry in Alberta.

Mr. Gitelman uses the example of polyhydroxy butyrate or biodegradable plastic. The North American demand for this product will reach 100,000 tonnes per year by 1990, he predicts. A total of 120,000 tonnes of starch would be needed to produce one-third of the annual demand for this new product. He says we must produce the strategy to attract plants

like this to Alberta.

"Agriculture is our second-most important renewable resource," says Mr. Gitelman, noting that people are the most important. "Agriculture and industry could cooperate to combine whole crop harvesting with agricultural refineries. Alberta is an ideal place for Nutrient Valley." Among the advantages of the province, he counts an excellent Food Science Department at the University of Alberta, the Food Processing Development Centre in Leduc, the University's Faculty of Medicine in Edmonton, and excellent agricultural research and marketing facilities."

One other Alberta resource that might possibly be put to such good use, says Mr. Gitelman, is the Alberta Heritage Fund. He ventures that it could be used to supply the leadership and infrastructure necessary for such an ambitious but potentially-rewarding endeavor.



Crumbs!

There's more to wheat than meets the eye



Dr. Tony Evans of Norac Technologies

There are few things Canadians do better than grow wheat, says Dr. Tony Evans, so its high time we did more with it than sell it on export markets. "Sure, we can sell it," he says, "but we should also think of this crop as starch, high fructose syrup, alpha tocopherol and specialized bran products! We must think this way if we are to optimize our potentials in this province."

A continuous extrusion process, says Dr. Evans, can be used to cook and expand grains to produce

*"We grow wheat, and then
we import wheat germ oil
from West Germany."*

crumbs, snack foods and breakfast cereals. Crumbs may not be a glamorous product, but they are used in a wide variety of processed foods, including battered fish sticks and take-out fried chicken. In the United States, some 225,000 tonnes of grain are used annually to produce crumbs.

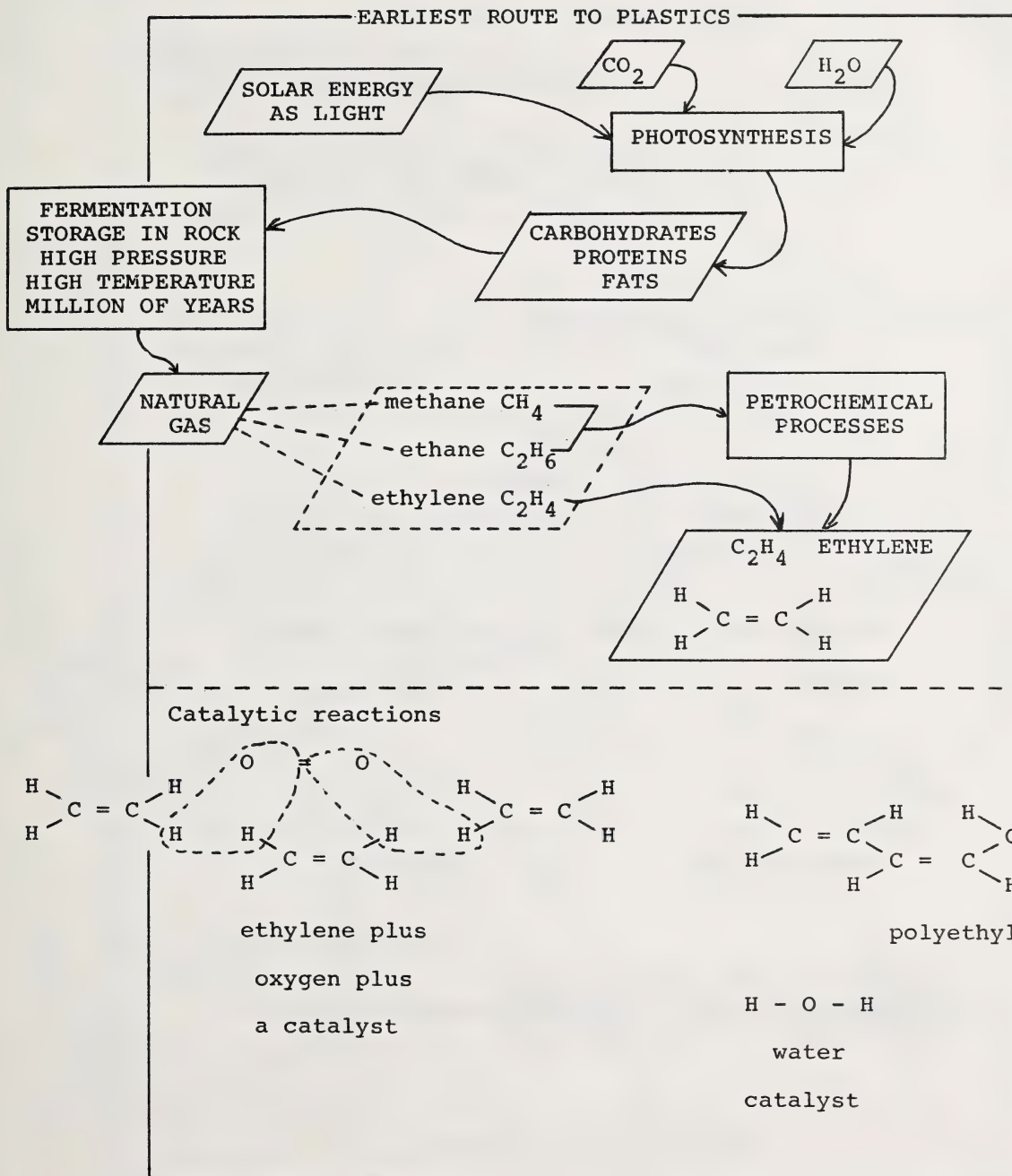
A good place for prairie wheat growers to start, says Dr. Evans, would be to process wheat into starches that could be used to produce chemicals, glues, dyes, and myriad other products. "Starches are one of the great industrial raw materials," he says. "We could begin producing to meet our domestic re-

quirements and afterwards enter the export marketplace."

Dr. Evans' firm, Norac Technologies, uses a super-critical extraction process to draw valuable compounds and products from grains and special crops. Highly compressed carbon dioxide is used to absorb specific oils or flavours from the raw material. He has extracted wheat germ oil from wheat germ, as well as essential oils from coriander, caraway and dill. He has also extracted gamma linolenic acid (GLA) from borage, a crop which grows well in Alberta. Dr. Evans adds that super-critical extraction or refining of canola oil without the use of hexane, is a possibility for the future.

One of the great barriers to the building of agricultural processing industries in Canada, says Dr. Evans, has been a domestic policy which has encouraged the export of cereals in preference to processing them at home. "We grow wheat," he says, "and then we import wheat germ oil from West Germany." This is encouraged by Canada's two-tier pricing policy for wheat, which he says "discourages the competitiveness of the processing industry in this country." But he insists the problems are not insurmountable. "I've been reading in the news lately that the two-tier pricing system may be abandoned," he says, "and if it can be abandoned and replaced with something that will still protect farmers, things will get exciting. We have the best wheat in the world here. There will be wonderful opportunities." A healthy processing industry, he says, would create more jobs, lead to a stronger economy, and develop the kind of processing technology Canada needs.

DATA SHEET THREE

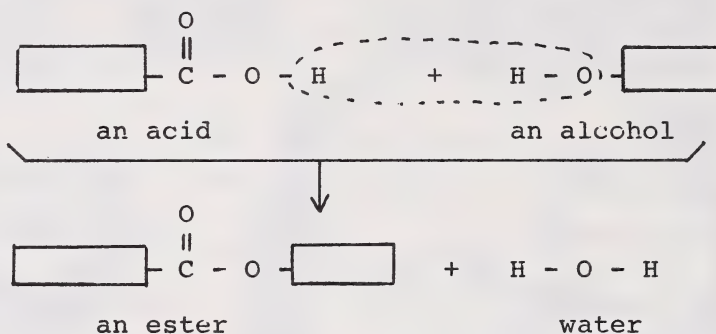




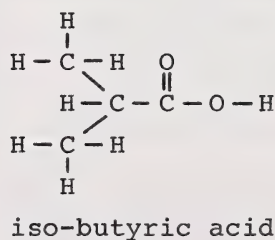
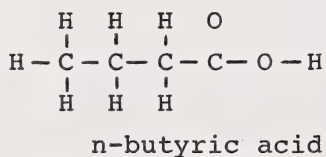
DATA SHEET FOUR

A biodegradable plastic from:

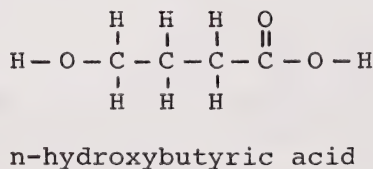
- Butyrate - an ester of butyric acid
- Ester - any of a class of often fragrant compounds formed by the reaction between an acid and an alcohol, usually with elimination of water



Butyric acid - either of two isomeric acids



Hydroxybutyric acid - a hydroxy derivative $\text{C}_4\text{H}_8\text{O}_3$ of butyric acid



TASK SHEET ONE

RESEARCH QUESTIONS



Question One:

How can organic chemists link ethylene units into polyethylene chains?

Question Two:

Can polyethylene chains be branched?

Question Three:

How does branching affect the characteristics of polyethylene?

Question Four:

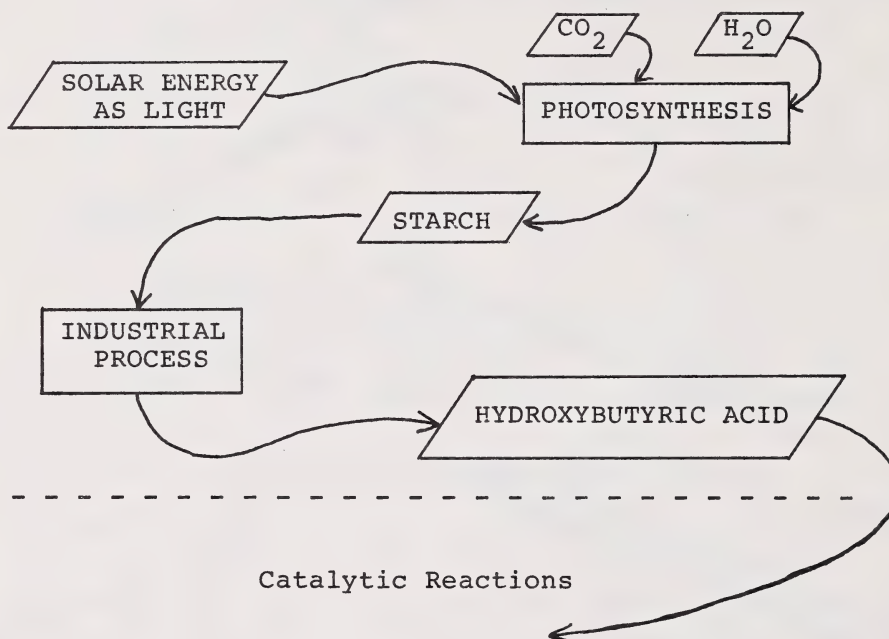
How do chemists and chemical engineers control the structure and characteristics of poly-ethylene?



TASK SHEET TWO

POSSIBLE ROUTE TO NEW PLASTICS

In the space below draw the structural diagrams of two molecules of n-hydroxybutyric acid and show how they can combine to make an ester-linked polymer plus a molecule of water.



ACTIVITY 12

Designer Genes - Cut to Fit Your Needs



Objective:

Students will act as a citizen review panel and make recommendations for a genetic engineering research policy.

Curriculum Fit:

Science 30, Unit III
Genetics

Science Concepts:

Genetic engineering involves fundamental principles from biological science.
Genetic engineering can create new forms of life.
Applications of genetic engineering and biotechnology involve social and ethical dilemmas.

Skills:

Analyse critically the possible impact on society of scientific research and technological development in genetic engineering.

Attitudes:

Appreciate that new technologies are often developed in response to a problem.
Appreciate the interrelationships among science, technology and society.

Agriculture Concepts:

Diversity
Technology Intensity

Cognitive Level:

Synthesis, Evaluation

Materials Required:

Included

Time Required:

One period for group work.
One period for presentation and decision.



BACKGROUND - For the Teacher

An important function of the Science 10, 20, 30 sequence is to produce lay citizens that can respond intelligently to scientific information, concerns and proposals. One way in which citizens presently act on scientific matters is as members of advisory committees.

In this lesson your students role play as members of a citizen's advisory committee on genetic engineering. Based on a recent article each group will prepare the genetic engineering portion of an Alberta Research and Development Policy. Following presentations by each working group, the class will discuss results in order to identify critical factors leading to their own decisions.

This lesson will be most effective when your students have already acquired some of the genetics background from this unit.



PROCEDURE

Part 1

Preparation:

1. Decide on a method for choosing task groups.
2. Make one copy of the enclosed reading for each student and one copy of Task Sheet One for each task group.
3. Distribute the article Genetic Diversification and ask students to read it for the start of their new class.

Part 2

Introduction:

4. Explain that much of government policy development calls on citizen advisory boards for lay participation, and inform the class that they will be taking on that role in this activity.
5. Divide the class into working groups of five and distribute one copy of Task Sheet One to each group.

Part 3

Activity:

6. During this first period students develop a group response to each question and prepare a 5 - 7 minute oral presentation. Assist groups as needed to ensure progress.
7. In a second class period each group presents its responses to the questions as if they were advisory group recommendations.

Part 4

Conclusion:

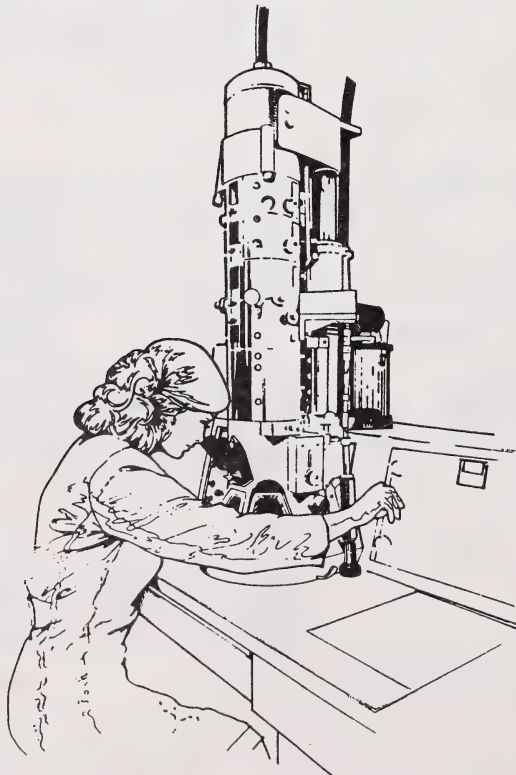
8. Once all reports have been made, lead a discussion about how each group arrived at its recommendations.

DISCUSSION QUESTIONS

1. Why do people automatically fear the idea of genetic engineering?
2. How did each group arrive at a dollar total for the proposed research allotment? What additional information would groups need to make a real recommendation?

RELATED ACTIVITIES

1. Invite a genetics researcher or student to speak to the class on genetic engineering.
2. Choose a specialized breed of any plant or animal. Research how and when it was developed, and what further development is needed today.





TASK SHEET ONE

Welcome students.

Your group has been chosen to serve as a Citizen's Advisory Panel to assist in developing an Alberta Research and Development Policy. Your investigation is to focus on genetic engineering, and your report should deal with four issues.

1. From the data package supplied, identify all genetic engineering projects and rank them according to your groups opinion of their value.
2. Recommend 5 other problems in any of the life sciences that should be addressed by genetic engineers.
3. Identify 3 potential dangers arising from genetic engineering, and propose safeguards for each.
4. Determine how much money should be allotted to genetic engineering research in Alberta each year, and tell where it should come from.

Your analysis and report should be ready for next class. You are to make a 5 - 7 minute oral presentation to the class, and this must be accompanied by a point-form outline of your responses for your teacher.



Genetic Diversification:

How biotechnology will transform the agricultural economy

by Fay Orr

Surrounded by potted plants, shelves of shoot-containing jars, and grow-lights, he looks more like a greenhouse keeper than an eminent scientist. But Dr. Aladar Szalay is one of the world's foremost molecular biologists, and the greenery encompassing him is no ordinary assortment of leaves, stems and stamens. It is as varied as fish and fruitflies. No, Dr. Szalay is not engaged in a whimsical battle of wits with Mother Nature. He heads the University of Alberta's fledgling research chair in plant biotechnology and the work he and others like him are doing promises to affect the western world as profoundly as the microcomputer.

The Hungarian-born Szalay came to

Alberta last January from New York, where he co-ordinated the DNA synthesis facility at Cornell University's Boyce Thompson Institute for Plant Research. He was brought here thanks to \$500,000 worth of grants from Canadian Pacific Ltd. and Alberta Agriculture, and the urging of Dr. Roy Berg, the University of Alberta's Dean of Agriculture and Forestry. "Research institutions throughout North America are making strides in plant biotechnology," says Dr. Berg. "We'll have to work like the devil to keep ahead here in Alberta." Why should Alberta worry about keeping up? Simply put, biotechnology has the potential to create new crops, new fertilizers, new pesticides, new animals and new drugs that could generate

"Research institutions throughout North America are making strides in plant biotechnology. We'll have to work like the devil to keep ahead here in Alberta."

—Roy Berg



Dr. Aladar Szalay

"In genetic engineering we take pieces of DNA from here and there and put them together to produce something better than what is found in nature."
—A. Szalay

billions of dollars a year in sales and savings for farmers and pharmaceutical companies.

Within three years Dr. Berg hopes to establish an on campus Biotechnology Centre wherein Dr. Szalay and his colleague Dr. William Langridge, also of Cornell, can co-ordinate the biotechnical efforts of the Faculty's plant, food, and animal scientists. But for now Dr. Szalay is stationed at the brightly coloured and

with pea plants he learned that plants contain factors which contribute to the inheritance of specific characteristics. Later scientists found these factors to be genes, which are contained in the chromosomes of every cell. In the 1940s, a Canadian, Dr. Oswald Avery, discovered that genes were made of deoxyribonucleic acid (DNA), a long, thin string of chemicals. In 1953 at Cambridge University scientists Dr. James Watson and Dr. Francis Crick

found that DNA consisted of two intertwined strands, each composed of chains of four different chemical bases called A,C,G, and T. Within a strand, of DNA, the chemical blue print for all living creatures, Watson and Crick paved the way for recombining or engineering DNA to suit human purposes.

Researchers during the early 1970s developed the recombinant DNA technologies required to manipulate and



Dr. William Langridge

airy Alberta Research Council building in south Edmonton. There he, Dr. Langridge, and several graduate students from around the world are probing the secrets of gene regulation. Their research could lead to the development of plants resistant to frost, disease and insects. It could result in faster growing forests, plants that produce new medicinal compounds and/or weed-killing toxins, and crops custom-made for Alberta's climate. The possibilities are truly endless.

"Biotechnology involves the use of molecular genetic tools to give economically important systems (plants and animals) new characteristics that can't be achieved through conventional breeding," says Dr. Szalay. "In genetic engineering we take pieces of DNA from here and there and put them together to produce something better than what is found in nature."

The early foundations of genetics were laid by the 19th century monk Gregor Mendel. Through breeding experiments

transfer genes from one cell to another. They learned how to use a variety of enzymes to cut genes apart and splice them back together. Today, says Dr. Szalay, "We can take a gene from just about any organism, study it, understand it, modify it, make more of it, return it to its original host or transfer it to cells in completely different organisms."

By the end of the 1970s biotechnology was becoming a major business as university scientists, aware of the commercial potential of their work, began setting up companies. Among the new firms were Genentech, Calgene, Biotechnica International of Cambridge, Mass., and its Calgary-based affiliate, Biotechnica Canada Ltd. Existing drug and chemical companies such as Monsanto and Eli Lilly also began spending enormous sums on biotechnical research and forging links with university laboratories. To date their greatest successes have occurred with bacteria. These simple, single-celled organisms contain plasmids, small loops of self-

replicating DNA which float about in the cell and are ideal for the insertion of new genes. In the late 1970s Genentech isolated the gene for human insulin, inserted it into an *Escherichia coli* bacterium, and left the altered organism in a fermentation tank to multiply. As the bacterium multiplied, it mass-produced human insulin which was purified and sold under the brand name Humulin.

Bacteria have also been turned into industrial and agricultural products capable of, among other things, digesting crude oil or fertilizing plants. Currently Dr. Szalay is attempting to develop multi-purpose microbes by "piggy backing" desirable genes onto already useful bacteria. For example, he says, it may be possible to give fertilizing bacteria the ability to kill plant-threatening microbes like fungi and nematodes.

Plants and higher animals are more difficult to engineer. Their cells lack plasmids and so more sophisticated methods are needed to insert new genetic material into them. What's more, the new genes must be properly controlled to switch on and off at the right time and place. For example, an insect-repelling gene should produce its toxin only when the insect is in season and only in those parts of the plant likely to be attacked. "We can put any gene we want into any plant," says Dr. Szalay. "But gene expression varies from organ to organ. Not all genes are active in every cell. We must learn how to control the signals that turn genes on and off in order to engineer intelligently." Identifying and isolating "switches" and hooking them to genes is a major component of Dr. Szalay's work. "The switch is like the locomotive on a train," he says. "Without it, the train isn't going to move."

To find switches Dr. Szalay uses luciferase, a gene found in the *Vibrio harvey* bacterium, which lights up whenever it connects with a switch. The switch is then chemically isolated and hooked to a "gene of interest" —for example, the anti-freezing protein gene found in fish or the heat-resistant gene found in fruitflies. (Virtually any known gene can be chemically assembled in the laboratory with a computerized DNA synthesizer). This

switch-gene combination is then chemically connected to "marker" genes (luciferase again, plus another gene resistant to a particular drug). All of this genetic engineering is accomplished in a test tube (*in vitro*) by a variety of enzymes that cut and paste DNA into the desired sequence. Once the genetic material has been "designed" it is inserted into bacteria, which quickly produce copies of the stuff, thus giving the scientist plenty of material with which to experiment.

Next Dr. Szalay tries to transfer the genetic material into selected plant cells. This he can do in one of several ways. He can blast the cells with tiny DNA-soaked tungsten balls fired by a particle gun, he can remove the cell walls with enzymes and invade the resulting photoplant with bacteria, or zap them with short, sharp electric pulses (electric poration, a procedure developed by Dr. Langridge). The basic idea is to open the cell membrane long enough to allow the foreign DNA inside where it is somehow incorporated into the chromosomes and passed on to subsequent generations of cells.

To find out if the gene transfer has succeeded, Dr. Szalay puts the petri dish of cells into the chamber of a computerized "lowlight video image analyzing system." There the cells are scanned by an extremely sensitive camera capable of detecting the light emitted by the marker luciferase genes. Plant cells which have taken up the foreign, luciferase-containing DNA will give off light and show up clearly on the coloured computer screen connected to the photo chamber. Dr. Szalay places these cells into a nutrient-rich medium, where they develop into a callus, a cluster of undifferentiated cells resembling coloured sugar crystals. The callus is placed in another medium containing hormones that encourage leaves and roots to grow. Finally, the plantlet is potted and grown to maturity. Every cell in the "regenerated" plant contains a copy of the transferred gene. Dr. Szalay then observes the plant for the new gene's effect.

Along with developing a keener understanding of gene regulation, Dr. Szalay will also concentrate on engineering plants capable of producing medicinal com-

"For example, he says, it may be possible to give fertilizing bacteria the ability to kill plant-threatening microbes like fungi and nematodes."

—A. Szalay

"By controlling organisms we could extend the shelf-life of meat to 45 or 60 days."

—Michael Stiles

pounds, natural food additives and fragrances. The development of such crops would enable Alberta farmers to diversify, says Dr. Szalay. "Farmers could be encouraged to grow transgenic crops. They could build greenhouses and harvest drug-producing plants for pharmaceutical companies. Producers could switch from traditional high-volume, low-value crops (grains) to new low-volume, high-value ones."

In recent weeks Dr. Szalay has begun collaborating with other molecular scientists in the Faculty of Agriculture and Forestry. Among those who will be working with Dr. Szalay are plant scientist Dr. Anne Flanagan, animal scientist Dr. Keith Salmon, forest scientist Dr. Francis Yeh and food scientist Dr. Michael Stiles. "Eventually," says Dean Berg, "Dr. Szalay and the Biotechnology Centre will become the focal point for all campus people doing biotechnical work, whether they be biochemists, biologists, or pharmacists. Genetic manipulation at the molecular level is something that crosses many disciplines."

Dr. Salmon, a 1981 University of Alberta agriculture graduate, returned to the Faculty in August 1986 with his PhD in animal genetics. He is working on several projects, including the attempt to isolate the bovine casein gene, which produces one of the major proteins found in milk. Dr. Salmon wants to bolster the gene's casein-producing ability so that Alberta dairy farmers can produce protein-enriched milk and so fetch higher prices for it—should the pricing system be changed to reflect differing protein contents in milk. Once isolated and improved, the gene would be transferred to fertilized bovine eggs.

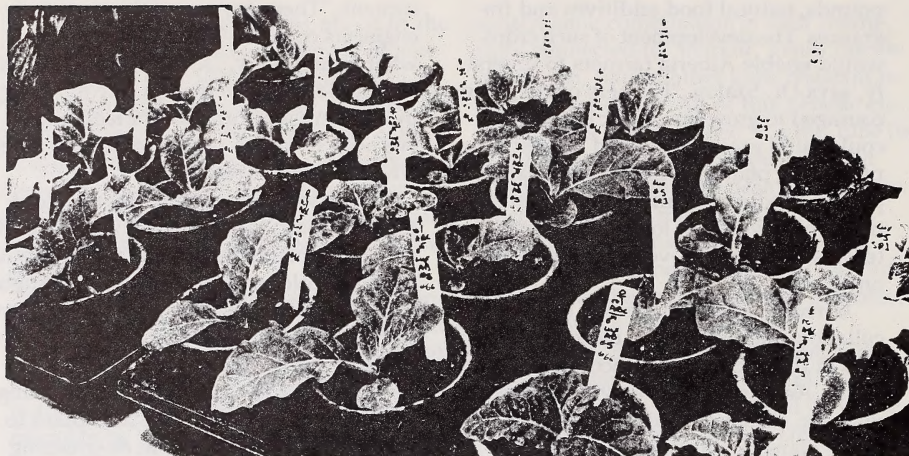
Dr. Salmon also hopes to identify and isolate the genes controlling growth in unusually large cattle and transfer them to cattle embryos. "Instead of 20 years to selectively breed bigger cows, we could do it in one gestation," he says. Dr. Salmon is not trying to create "super" cows the size of elephants, a possibility that has been contemplated by other scientists. Rather, he wants to gain a better understanding of growth regulating genes in order to increase cattle growth rates and lean meat

content. "There are lots of things genetic engineers could do, but we must decide what is necessary," says Dr. Salmon. "We should be trying to manipulate efficiency by deriving more growth for less input. We need to talk to producers and ask them what it is they need done."

An oilseed developmental physiologist, Dr. Flanagan is attempting to develop canola plants better able to withstand Alberta's cold winters and frequent August frosts. Dr. Flanagan, another University of Alberta graduate, worked for several years at Agriculture Canada's Plant Research Centre in Ottawa before returning to Edmonton last year. She also plans to study the genes involved in de-greening canola seeds. Unseasonal frosts can cause canola seeds to remain green instead of maturing into a yellow colour. Because this green seed produces a lower quality, lower-priced green oil, it must be de-greened. In 1982, says Dr. Flanagan, 38 per cent of western Canada's canola crop required de-greening. A seed genetically engineered to de-green itself could save producers millions of dollars. Dr. Flanagan hopes to develop freeze-tolerant canola plants within one to three years. "Using traditional breeding methods, it would take at least 15 years."

In the Food Sciences Department, Dr. Michael Stiles is attempting to genetically manipulate the microorganisms found in meat. His immediate aim is to lengthen the shelf-life of red meats vacuum packed in "modified atmosphere" containers. The anaerobic environment in such packaging causes different types of bacteria to flourish. Microbes that normally render meat rank and putrid are killed off by other microorganisms that give the meat a sour taste after about 30 days. Dr. Stiles wants to engineer bacteria which produce less sourness and are more effective at destroying undesirable microbes. "By controlling organisms we could extend the shelf-life of meat to 45 or 60 days. We might also be able to remove the need for food additives and preservatives."

Two years ago Dr. Francis Yeh came to the University of Alberta to establish an industry chair in forestry genetics. Supported by the Alberta Paper and Products Association, the Alberta Forest Service,



"We could engineer trees suited to marginal environments and grow forests where none has existed before."

—Francis Yeh

and the National Science and Engineering Research Council of Ottawa, Dr. Yeh is conducting genetic research in lodgepole pine, white spruce, black spruce and jack-pine. Formerly the technical adviser for tree improvement in British Columbia, Dr. Yeh says forest biotechnology is still in its beginning stages. "For now we are concentrating on finding the best way to transfer genes into trees," he says. To date, he has transferred a corn gene into lodgepole pine. Through collaboration with Dr. Szalay, he will use the luciferase system to identify and transfer genes resistant to such diseases as rust, budworm and pinebettle. He will also attempt to genetically improve tree growth rates and wood quality and develop secondary chemical products of value to the pharmaceutical industry. For example, the Boston Fir produces a chemical used to coat contact lenses.

Genetic engineering could result in the marriage of the concepts of agriculture and forestry, says Dr. Yeh. "Instead of

strictly cutting and re-planting wild forests, we could engineer trees suited to marginal environments and grow forests where none has existed before." With some genetic manipulation, the rotation period of hardwoods like aspen could be reduced to 10 from 25 years, suggests Dr. Yeh. Such fast growing trees could conceivably be grown by farmers as alternative crops, as could trees capable of producing secondary chemical compounds.

Eventually Dr. Szalay will collaborate with private industry as well. "We should become so good at genetic manipulation that industry looks to us for help in applying this technology. We will perfect the technology, then offer to help companies use the technology to develop new products and solve problems." The establishment of the plant biotechnology chair is definitely a milestone for Alberta, says Dean Berg. "It should advance biotechnology in this province by at least 10 years."



N.L.C. - B.N.C.



3 3286 08716361 0